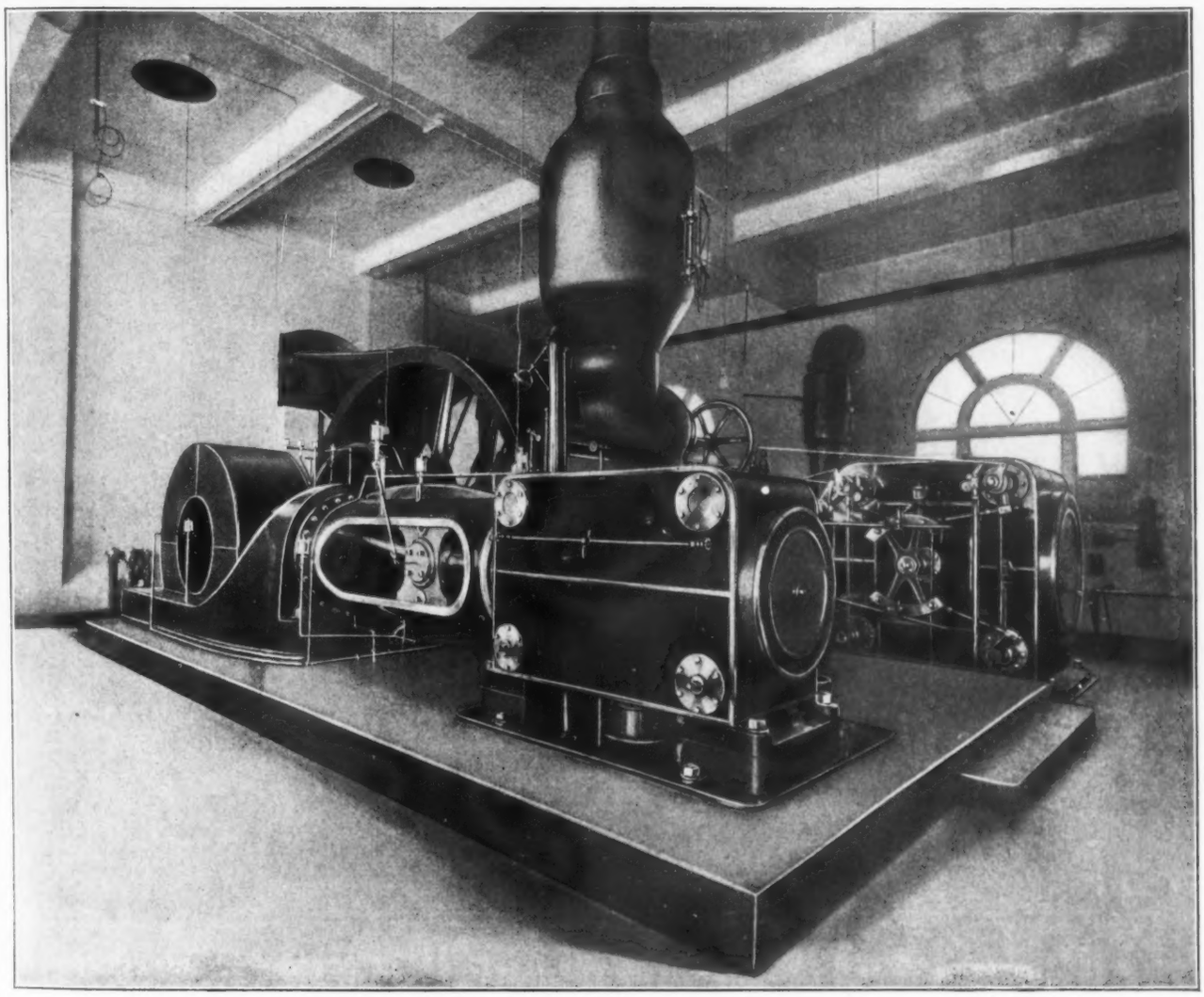
$2.00 per Year SEPTEMBER 8, 1908. Price 5 Cents

POWER AND THE ENGINEER

ISSUED WEEKLY BY THE HILL PUBLISHING COMPANY, 505 PEARL STREET, NEW YORK.

Vol. 29. Index to Advertisers and Classified Index Following Reading Matter No. 10.

Twin City CORLISS ENGINE



1,500 H. P. Cross Compound Twin Citys Corliss Engine—Rope Drive—just Installed by us in a New Flour Mill in Minneapolis. Fly Wheel 18 ft. Diameter, Grooved for 24 2-in. Ropes.

When considering the purchase of a new engine, do not fail to have a talk with one of our Engineers, who will gladly call upon you if requested. Owning one Twin Citys you will never be satisfied with any other.

Brochure No. 101 sent upon application.

MINNEAPOLIS STEEL AND MACHINERY CO MINNEAPOLIS

The Boiler Tube Cleaner That Makes Good

Wouldn't you like to have a boiler tube cleaner that removes every bit of scale—not merely some of it ?—a tube cleaner that is easy to operate—that does rapid work—that is built on such simple principles and so strong that it will outlast any three cleaners of other makes ? Wouldn't you ?

You start saving lots of time, trouble and money the moment you have such a cleaner in your possession.

We want you to make a test, in one boiler, of

The Dean Boiler Tube Cleaner

Give it the severest kind of a trial and if it doesn't measure up to what YOU think a good boiler tube cleaner ought to be, you have only to box it up and return it at our expense. We'll loan you the Dean, free of charge, for this trial—and you may try it at your own convenience—we won't rush you.

Another thing—after you have paid for the Dean we give you six months' time in which to note the saving—actual saving—you have made, and if the tool hasn't paid for itself in that time you may return it even then and we'll refund the purchase price promptly.

Write for our Booklet, "From Water To Steam," anyway.

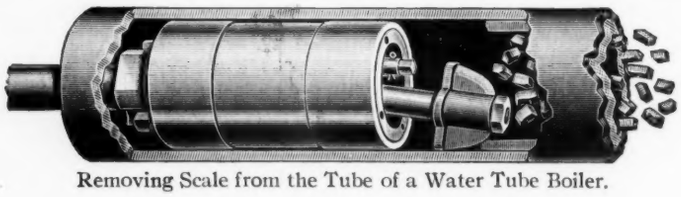
THE WM. B. PIERCE CO.,

JEWETT BUILDING,

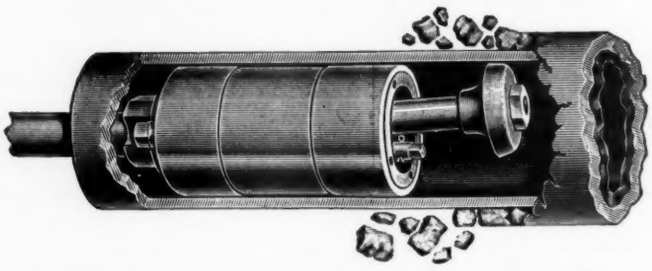
BUFFALO, N. Y.

LONDON OFFICE:
13-15 Wilson St., Finsbury, London, E. C.

CHICAGO OFFICE:
1001 Monadnock Bldg.. Chicago, Ill.

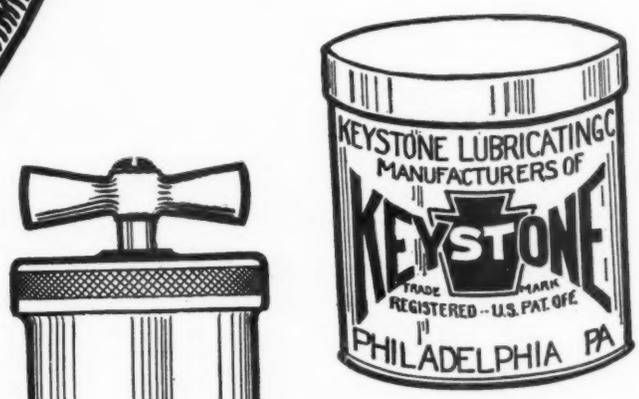


Removing Scale from the Tube of a Water Tube Boiler.

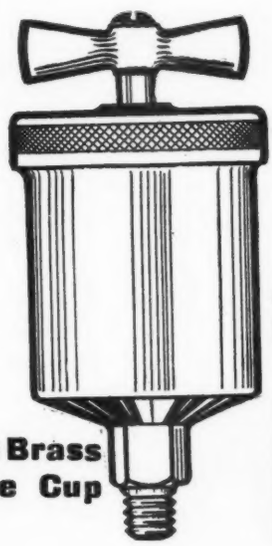


Removing Scale from the Tube of a Return Tubular Boiler.

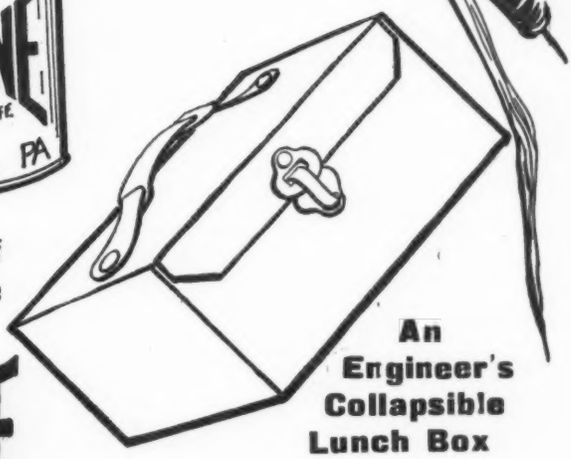
FREE



A Large Can Of Keystone Grease



A Fine Brass Grease Cup



An Engineer's Collapsible Lunch Box

KEYSTONE TRADE MARK REGISTERED U.S. PAT. OFF.

There's Always A Rush For Free Things

Send your request today for the three articles shown above. They're absolutely free because we want you to know

Keystone Grease

Fill out and mail to us the attached coupon at once. One pound of Keystone Grease lasts longer and lubricates better than 3 to 4 pounds of any other grease, or 4 to 6 gallons of the best lubricating oil. This offer is worth accepting.

KEYSTONE LUBRICATING CO.,

Dept. B. PHILADELPHIA, PA.

New England Office—10 Oliver St., Boston, Mass.
New York City Office—96 Warren Street.
Southern Office—610 Chartres St., New Orleans, La
Chicago Office—1210 Tacoma Bldg.
Northwestern Office and Warehouse—502 McPhee Bldg., Denver, Col.
San Francisco Office and Warehouse—268 Market St.

Name.....

Name of Firm.....

.....

Address in Full.....

.....

.....

H. P. of Engine.....

On what bearing will sample be tested?

.....

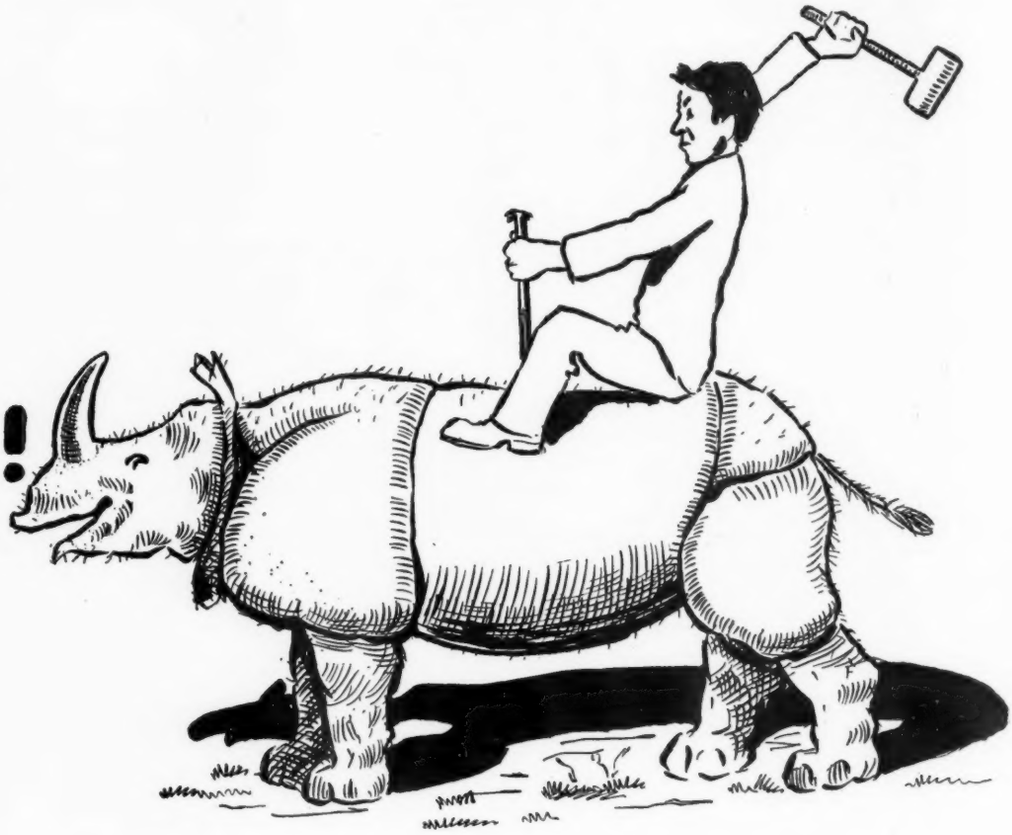
Its width.....

R.P.M.....

Size of tap for cup.....

Sept. 8.-08, Dept. B

IT'S NO USE!



Attempting to drive a spike into the hide of a Rhinoceros! The brute would only laugh at your feeble efforts, for there is nothing much tougher than his hide.

But, say, speaking of toughness, have you ever used

EBONITE,

the awfully-in-demand Black Sheet Packing? You know what a simple thing it is for superheated steam and high steam pressures to send most packings to the scrap heap in no time. Well, they can't do it with **EBONITE.** This packing is too tough a proposition for any joint to fool with.

OUR TRIAL OFFER

Pack the very worst joint in your plant with EBONITE, and if it fails to give better service than any other packing we will cheerfully refund you your money.

QUAKER CITY RUBBER COMPANY,

PHILADELPHIA PITTSBURGH CHICAGO

VOLUMES have been written authoritatively on the excess cost of producing a given horse-power in boilers that are coated with incrustation. Scale one-thirty-second to one-sixteenth inch thick increases the fuel consumption ten to fifteen per cent., and greater scale thickness means greater loss of heat.

In these times of keen competition, when the greatest manufacturing economy must be exercised, the Engineer, Superintendent, Manager, Owner, are vitally interested in reducing these unnecessary operating expenses.

That the boiler water troubles are being successfully handled by the Dearborn Company, in 11,000 steam plants, keeping boilers clean, and preventing waters from pitting boilers and tubes, the work being done under a combination scientific laboratory and practical engineering guidance, should appeal to the discriminating operator desiring to better results.

Gallon samples of waters required for analysis, after which we will tell you how to remedy the troubles you experience, and the cost to do it right.

DEARBORN DRUG & CHEMICAL WORKS

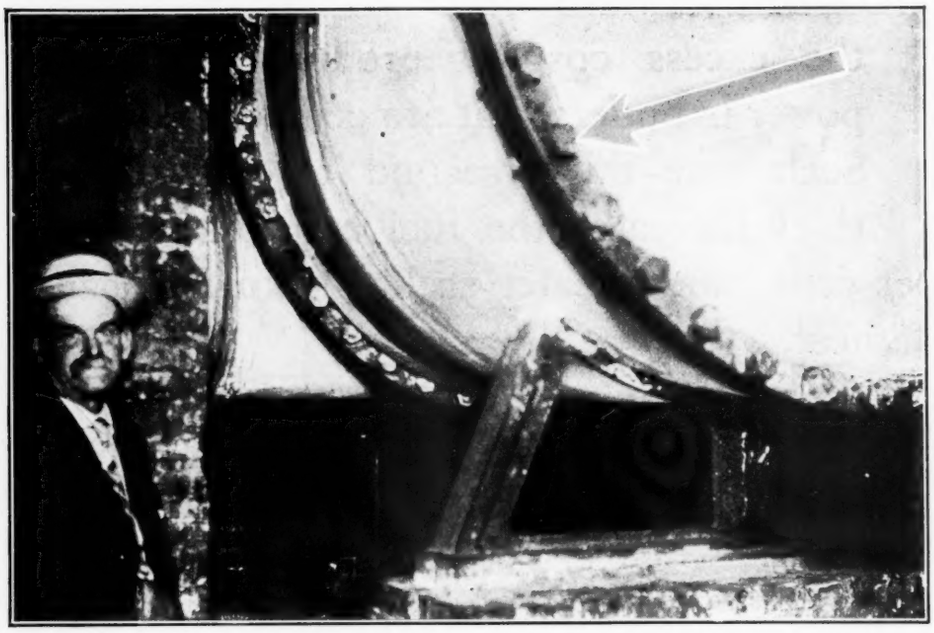
ROBERT F. CARR, President.

W. B. McVICKER, Vice-Pres. & Gen. Mgr. GEORGE R. CARR, Vice-Pres. G. W. SPEAR, Vice-Pres.
W. A. CONVERSE, Asst. Sec. & Chem. Dir. J. D. PURCELL, Asst. Gen. Mgr. H. R. BROWNING, Asst. Treas.

POSTAL TELEGRAPH BLDG., CHICAGO. 299 BROADWAY, NEW YORK.

BRANCH OFFICES

Philadelphia, The Bourse
Detroit, Majestic Building
Denver, Majestic Building
Boston, Oliver Building
Birmingham, First Nat. Bank Bldg.
Salt Lake City, Dooly Block
Pittsburg, House Building
St. Louis, Security Building
San Francisco, 301 Front Street
Buffalo, Morgan Building
Kansas City, New York Life Building
Milwaukee
Cleveland
Los Angeles, 325 E. Second Street
Cincinnati, Union Trust Building
St. Paul, 1237 Lincoln Avenue
Honolulu, 42 Queen Street
Havana, Esquina Mercaderes y Cortina de Valdes
Indianapolis
Peoria, Meyer Building



The above illustration is a partial view of a re-heating receiver between the high and low pressure cylinders of a 32 and 70 by 72 cross compound Corliss engine running a large cotton mill, at Fall River, Mass.

The receiver shell is of cast iron, made in two rings or sections. The receiver was furnished by the makers complete with packings ready for installation. After being installed for a short time the packing at center joining the shells gave out, and to repack the joint, owing to the necessity of disconnecting the exhaust pipe and coil, it was estimated would cost $350. The engineers in charge therefore decided to try **SMOOTH-ON ELASTIC CEMENT.** The engine was shut down on Saturday noon and the air pump kept running in order to produce a vacuum in the receiver. The **SMOOTH-ON ELASTIC CEMENT** was applied at the joint with a brush, the receiver still being quite hot. The vacuum drew the **SMOOTH-ON** into the joint, filling it completely, and the leak at once stopped. A torch was then applied to the joint, causing the **SMOOTH-ON** to quickly harden—the result was that a more permanent job was obtained than could be had by repacking the joint—and the whole job was done at a trifling expense.

This job illustrates one of the thousands of places where **SMOOTH-ON** may be used about a steam plant.

We will be glad to send a copy of our **SMOOTH-ON** instruction book to any engineer on application.

SMOOTH-ON MANUFACTURING CO.

572-574 Communipaw Avenue, JERSEY CITY, N. J., U. S. A.

Chicago Warehouse, 61 N. Jefferson Street. San Francisco Warehouse, 94 Market Street.
English Branch, 8 White Street, Moorfields, London, E. C.

Not An Ounce Of Fuel Wasted

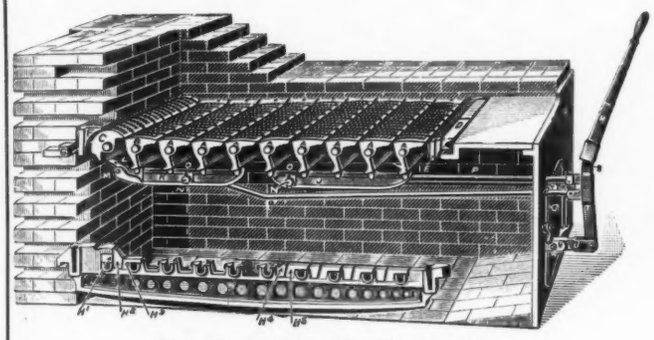


Plate No. 1. Normal Position of Grate.

Plate No. 2. Shaking Movement.

McClave's Grates and Argand Blowers

extract the heat units from any kind of fuel so thoroughly, that, where they are installed, it is possible to secure, from anthracite birdseye, rice, bituminous slack, screenings, duff, etc., the results you would expect only from the highest priced fuel.

With McClave Grates you can keep your fire even, and clean from front to rear without even opening the fire door.

Catalog "G" describes.

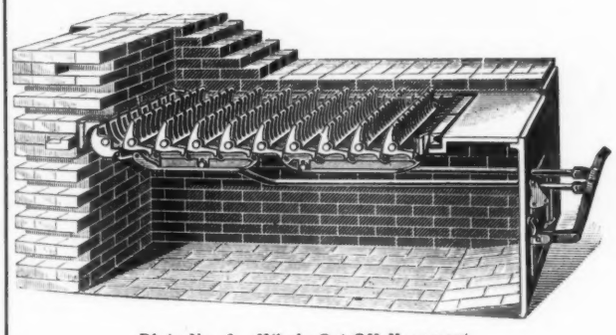


Plate No. 3. Whole Cut-Off Movement.

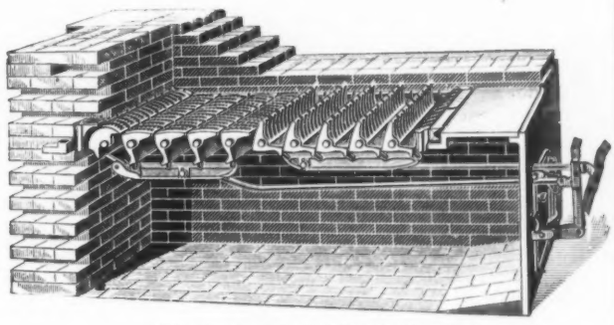


Plate No. 4. Divided Cut-Off Movement.

McClave-Brooks Co., Scranton, Pa.

BRANCH OFFICES: Charles N. Hays, Sales Agent, Fisher Building, Chicago; Empire Building, Pittsburg.

REASONS WHY

THE TRADE PENBERTHY MARK.

(Reg. U. S. Pat. off.)

AUTOMATIC INJECTOR

Always "Makes Good"

1st—It will work on higher pressure and handle hotter water.

2nd—It will lift further vertically on a greater range of pressure.

3rd—It delivers a maximum amount of water with a minimum amount of steam.

Try the PENBERTHY it never fails.

TRADE PENBERTHY MARK. "XL-96"

EJECTOR OR SYPHON

Has no equal in lifting or elevating liquids. Used Exclusively by the leading creameries, tanneries, breweries, brickyards, distilleries and dye houses in the country.

SPECIAL "XL-96" NON-ELEVATING EJECTOR

Heats liquids to a minimum; Lifts 28 feet; Uses less steam and delivers 33⅓% more liquid than any Ejector made. A trial will convince you.

CIRCULAR ON REQUEST.

The new "Engineer & Fireman" (80 page magazine) will be sent to any engineer who will send his name and address.

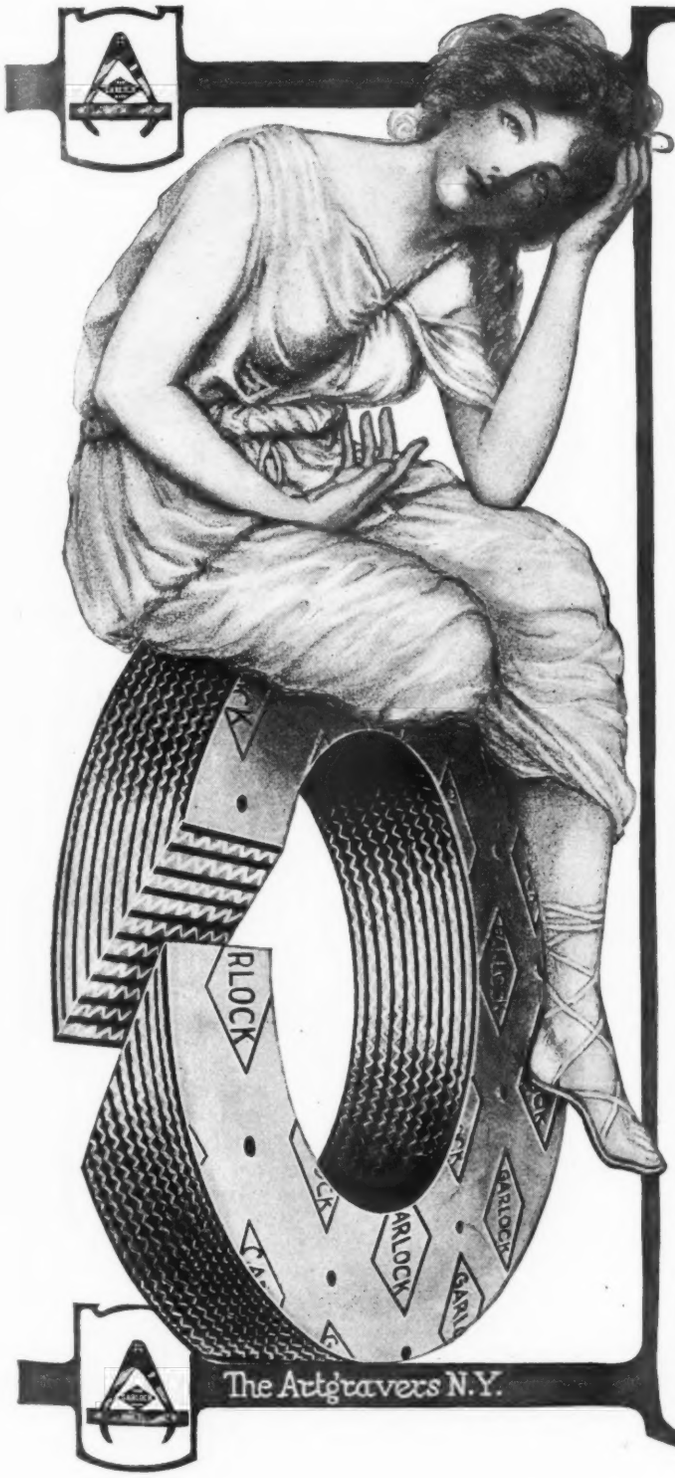
PENBERTHY INJECTOR CO.,

Largest Manufacturers of Injectors in the World

355 HOLDEN AVENUE, DETROIT, MICH.

New York Branch:—126 Chambers Street.
London, Eng. Branch:—W. H. Wilcox & Co., 23 Southwark St., S. E.

CANADIAN FACTORY:
Windsor, Ontario, Canada.



WELL

IT IS

GARLOCK PACKING

AND

GARLOCK FIBROUS

OR

PITT METAL PACKINGS

ARE THE BEST

YOU DO NOT HAVE TO TAKE OUR WORD FOR THIS. WE WILL BE GLAD TO PROVE IT TO YOU. THERE ARE NOW THOUSANDS OF ENGINEERS THAT KNOW IT.

PACKINGS IN ALL FORMS FOR ANY CLASS OF SERVICE OR AGAINST ANY CONDITIONS.

HOSE, BELTING, VALVES

AND

ENGINE ROOM SUPPLIES

HAVE YOU A COPY OF OUR CATALOG?

THE GARLOCK PACKING CO.,

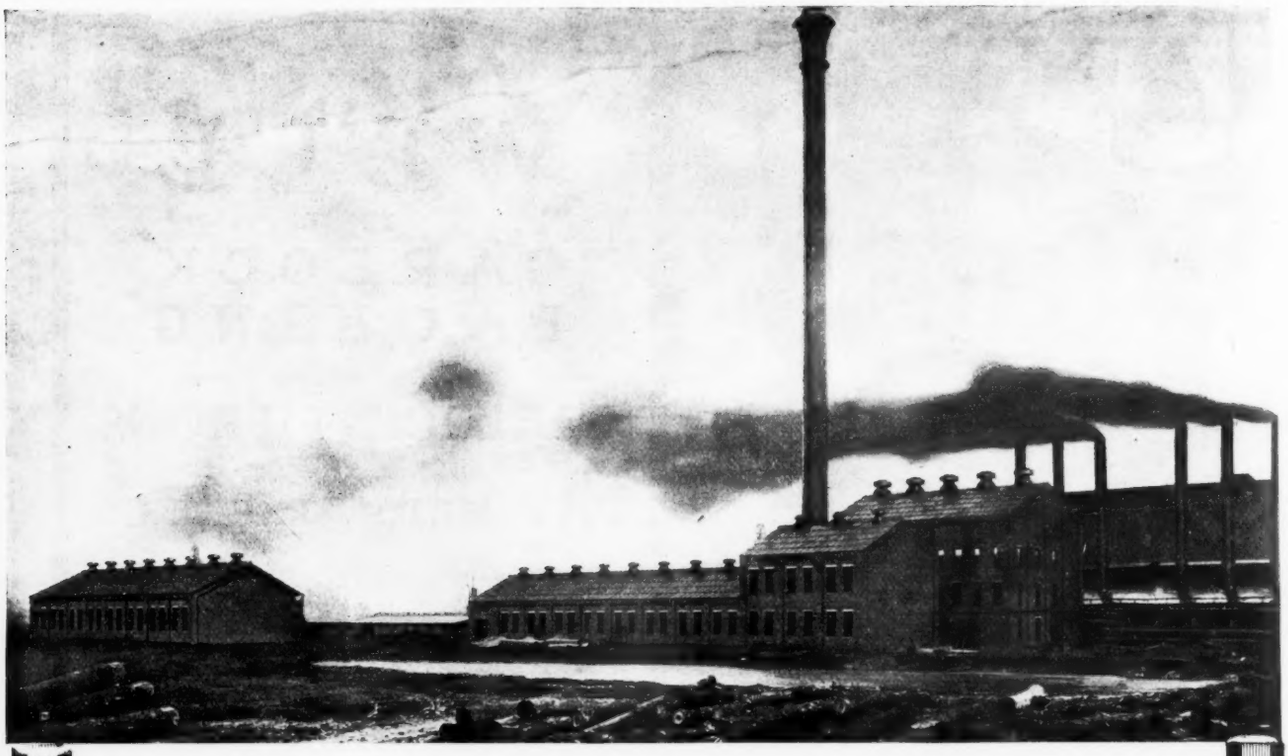
MAIN OFFICES AND FACTORY, - - PALMYRA, N. Y.

Philadelphia
San Francisco
New Orleans
Birmingham, Ala.
Ellwood City, Pa.
Cincinnati

New York
St. Louis
Pittsburg
Buffalo
Detroit
Norfolk

Chicago
Cleveland
Baltimore
Los Angeles
Portland, Oreg.
Salt Lake City

Denver
Seattle
Palmyra
Hamburg, Ger.
ETC.



The Most Modern Plants Are Being Equipped With "BURT" Ventilators

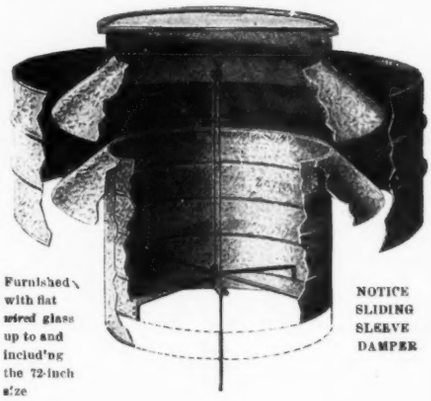
The plant shown here is that of the Ohio Salt Company, at Rittman, Ohio. Twenty-five "Burt" Combination Skylights and Ventilators were used in building this plant. The 5—48" "Burts" on the boiler and engine room do away with monitors.

"Burt" Ventilators are strong, neat, durable, absolutely storm-proof. They require no expense for operation and they never get out of order. Provide pure air and daylight for your employees to work in—install "Burt" Ventilators. Where the glass top feature is used, by the use of our patented sliding sleeve damper the ventilator can be closed yet the light is never affected—only ventilator on the market possessing this feature and fully covered by broad patents.

Metal top with sliding-sleeve damper (patented).

Send for our 96-page Catalog.

George W. Reed & Co., Montreal, Sole Manufacturers of "Burt" Ventilators for Canada.



Furnished with flat wired glass up to and including the 72-inch size

NOTICE SLIDING SLEEVE DAMPER

THE BURT MFG. CO., 232 Main St., Akron, O., U. S. A.

Largest Manufacturers of Oil Filters in the World.

The Du Bois Tandem Gas Engine

Salient Features of a New Single Acting Type Embodying Interesting Departures in the Application of Standard Principles of Design

BY GEORGE W. MALCOLM

The Du Bois Iron Works, Du Bois, Penn., has developed and is now building a line of single-acting tandem gas engines which embody several interesting features. Fig. 1 is a view of one of these engines, from which it will be evident that the design conforms to the standard European practice of locating the inlet valves in the top, the exhaust valves in the bottom and the valve-gear shaft alongside of the cylinders. Another characteristic European feature is the use of center-crank construction. Beyond these few points, however, the design cannot be said to follow strictly any classified practice.

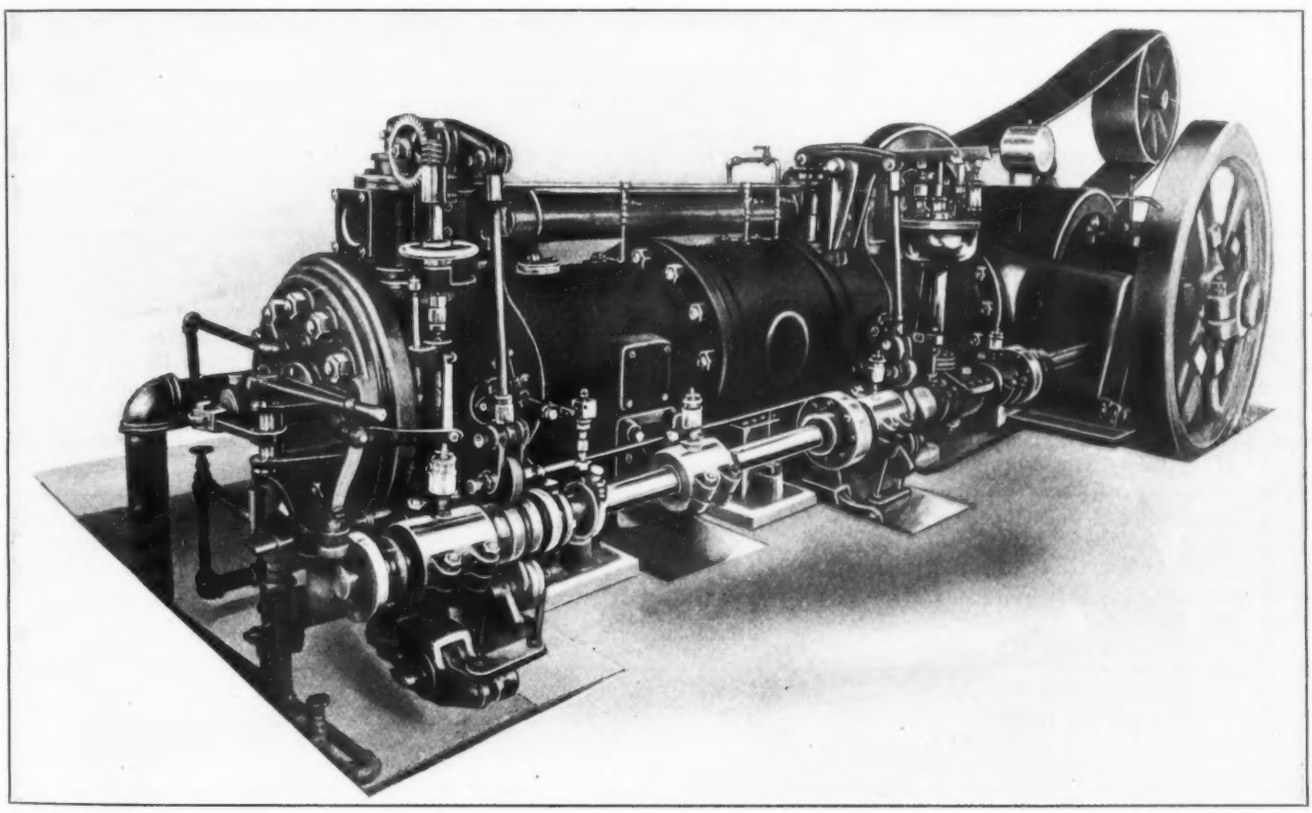


FIG. 1. DU BOIS TANDEM GAS ENGINE

Figs. 2 and 3 illustrate the frame and external cylinder construction. The frame, the cylinders and the intermediate distance piece are fitted to each other with circular necks and recesses concentric to the cylinder bore, and each cylinder rests on a pedestal bolted to the bed plate; in larger sizes the distance piece is also supported by a pedestal, as indicated in Fig. 2, but in smaller sizes the pedestal is omitted, as in Figs. 3 and 4. All of the pedestals slide on the soleplate to allow for expansion. The construction of the main frame is made clear by Figs. 2, 3 and 4. Fig. 1 further shows that the cam shaft is made in three pieces, with one coupling located at the junction of the main frame and the forward cylinder, and the other opposite the inter-cylinder distance piece. This makes it feasible to take the cylinders down without disturbing the cams and two-to-one gears.

Cylinders, Pistons and Crank

The longitudinal section, Fig. 4, gives an excellent idea of the internal construction of the engine and shows clearly the unusual method employed for packing the piston-rod hole in the rear end of the front cylinder. Instead of providing a stationary packing cage and having the rod slide through rings contained therein, the packing rings are put on the rod, like those on the piston, and they slide back and forth with the rod in a sleeve formed in the head of the front cylinder and a rearward extension of it. It might seem at first glance that this arangement would entail an unduly long engine structure, but the fact is that even if stationary packing rings were mounted in a housing in the cylinder head, the engine could not be shortened up without sacrificing accessibility to the rear piston and ease of dismounting the front cylinder head. Fig. 5 is a view of the piston rod with its packing rings and the flanged sleeve to which the rear piston is bolted.

The pistons are of the trunk type, and are built with convex heads in order to obtain the requisite strength with a moderate weight of metal.

The construction of the water jackets, cylinder heads, connecting rod and crank case is so clearly shown by Fig. 4 as to require no verbal description. The crank shaft, crank cheeks and pin are all cast

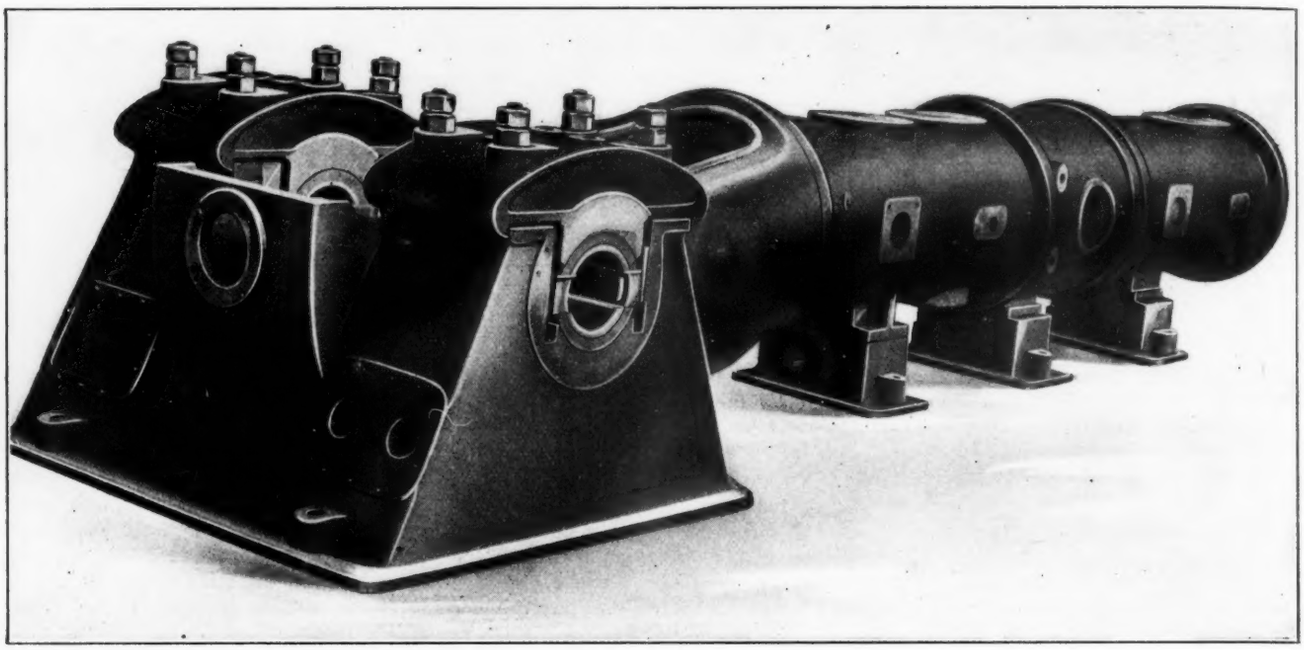


FIG. 2. FRAME AND CYLINDER OF DU BOIS GAS ENGINE

in one piece of steel and finished as indicated in Fig. 6; the balancing weights are bolted on, as shown in Fig. 10. This practice has been adopted in preference to the built-up type of crank as the result of several years of experience with both constructions by the designer of these engines, Peter Eyermann.

Valves, Valve Gear and Governor

Simple, flat poppet valves of forged steel, with beveled seats, are used throughout the engine, and the need for cooling the exhaust valves in larger sizes is obviated by the use of auxiliary exhaust ports uncovered by the pistons at the end of the forward stroke. These ports consist of a series of round holes through a rib connecting the water-jacket wall and the cylinder barrel, and they are drilled, instead of being cored, in order to obtain absolute accuracy in dimension and location. The inlet and exhaust valves of each cylinder are opened by a cam, two push rods and four rocker arms, as indicated in Fig. 7. Rollers are provided, of course, to take the thrust of the cam and to deliver the motion of the rocker arms to the valve stems.

One mixing valve serves both cylinders, as indicated in Fig. 4, where the mixing valve is shown immediately above the rear end of the piston-rod packing sleeve. Fig. 8 shows more of the details. The valve stem carries two pistons, the upper one controlling the air supply by varying the space between its upper edge and the top of the cage, and the lower one varying the gas supply by means of ports in its wall and corresponding ports in the wall of its cage. The proportion of gas to air is adjusted manually by means of the butterfly valves in the supply passages except in such cases as require variation of the mixture proportions simultaneously

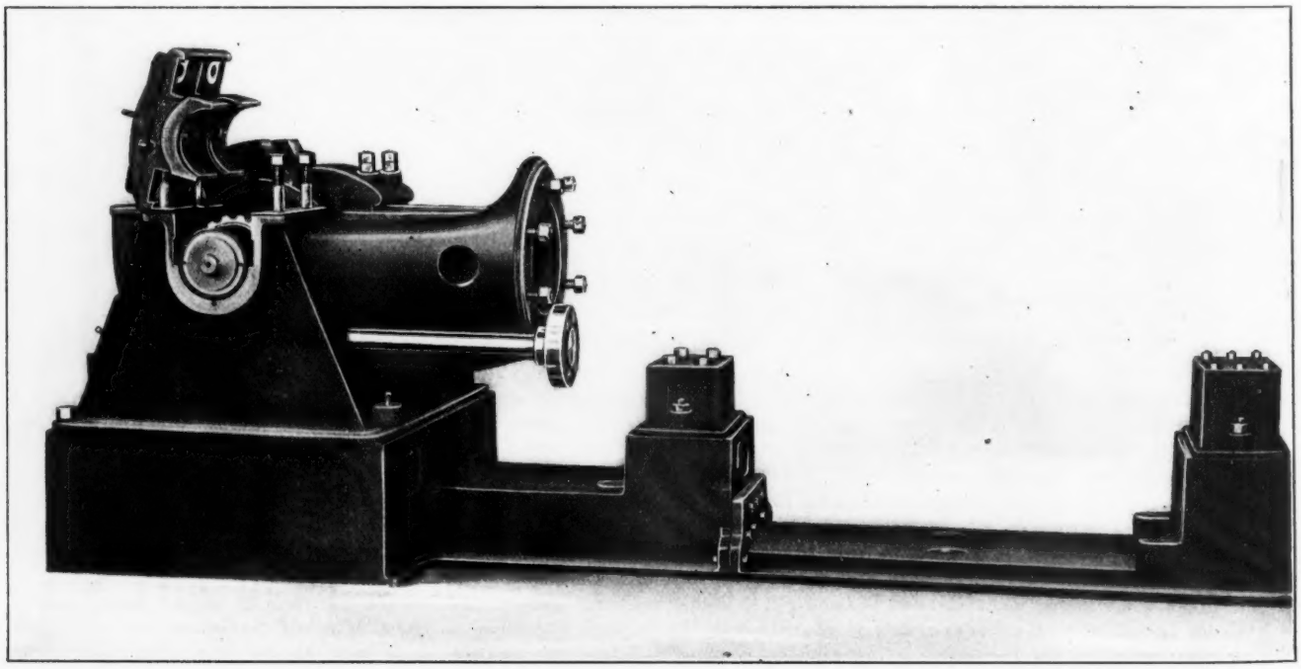


FIG. 3. MAIN FRAME OF DU BOIS GAS ENGINE

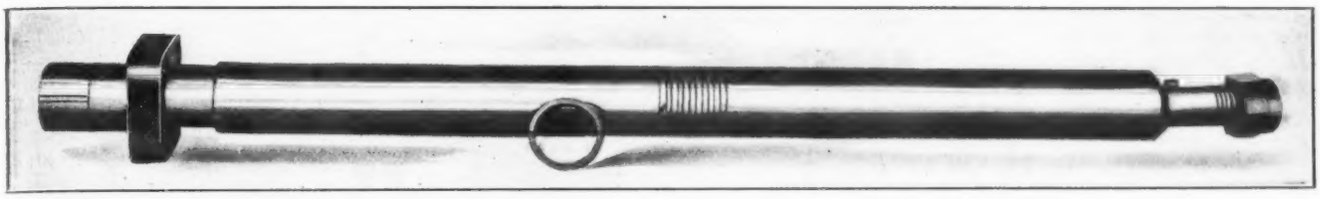


FIG. 5. PISTON ROD OF DU BOIS GAS ENGINE

with variation in the quantity of mixture admitted. For such conditions, the lever which raises and lowers the mixing valve is also linked to the butterfly valves, the linkage being adjusted so that the mixture is made richer as the load decreases (and the compression is reduced) and poorer as the load increases. This automatic mixture control is not necessary except when running on very lean gases. The mechanism is adjusted, usually, to give the best mixture proportions at full rated load, but a wide range of adjustment is practicable. Fig. 9 shows the linkage between the governor lever and the butterfly valves.

The governor is of the flyball type, but differs essentially from the common construction, as Fig. 8 clearly shows. The spindle is driven through spiral gears from the cam shaft and the balls and sliding member are inclosed in a stationary housing, as shown in Figs. 8 and 9. The governor gears are located between the forward cam and the main shaft; consequently, the angular velocity of the governor is not disturbed or made irregular by the tensional yielding of the cam shaft to the stresses imposed by the cams and valve mechanism. The cam shaft is driven from the crank shaft through spiral gears running in an oil bath, as illustrated in Fig. 10.

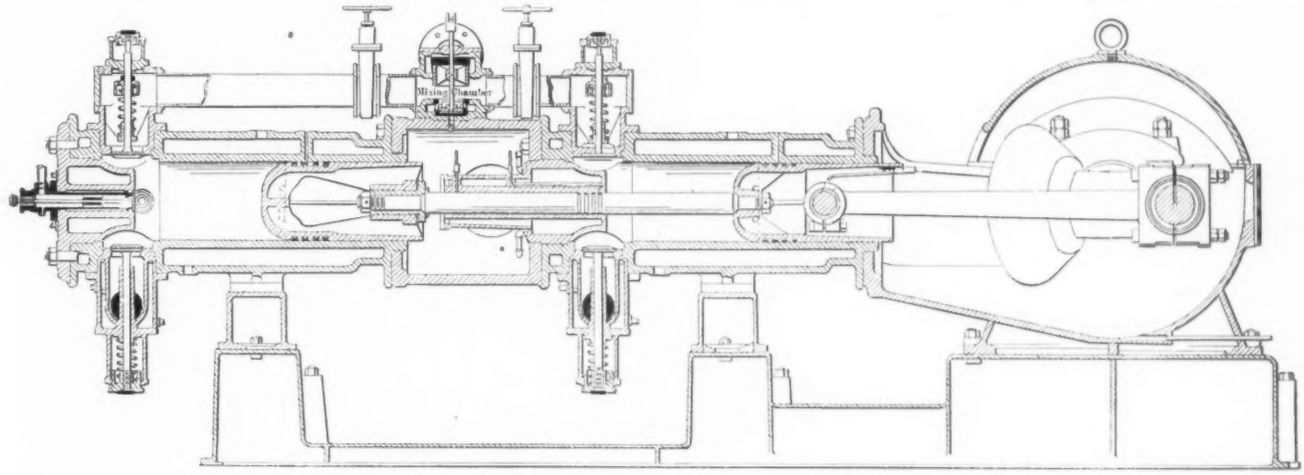


FIG. 4. LONGITUDINAL SECTION OF DU BOIS TANDEM GAS ENGINE

IGNITION

Igniters of the mechanical make-and-break class are used. The reciprocating mechanism which trips each igniter is driven by an eccentric on the cam shaft, as shown by Fig. 11. The individual igniter shown in the picture is timed by means of the vertical handle near the cylinder; this raises or lowers the horizontal finger with the bent end which trips the igniter, and thereby alters the point of ignition. The reach rod leading from the igniter mechanism to the left extends to the other igniter, and adjustment of this rod to the right or left retards or advances the timing of both igniters simultaneously. The levers to which the ends of this rod are pivoted are fastened to the ends of sleeves which are eccentric to the rocker studs, and the

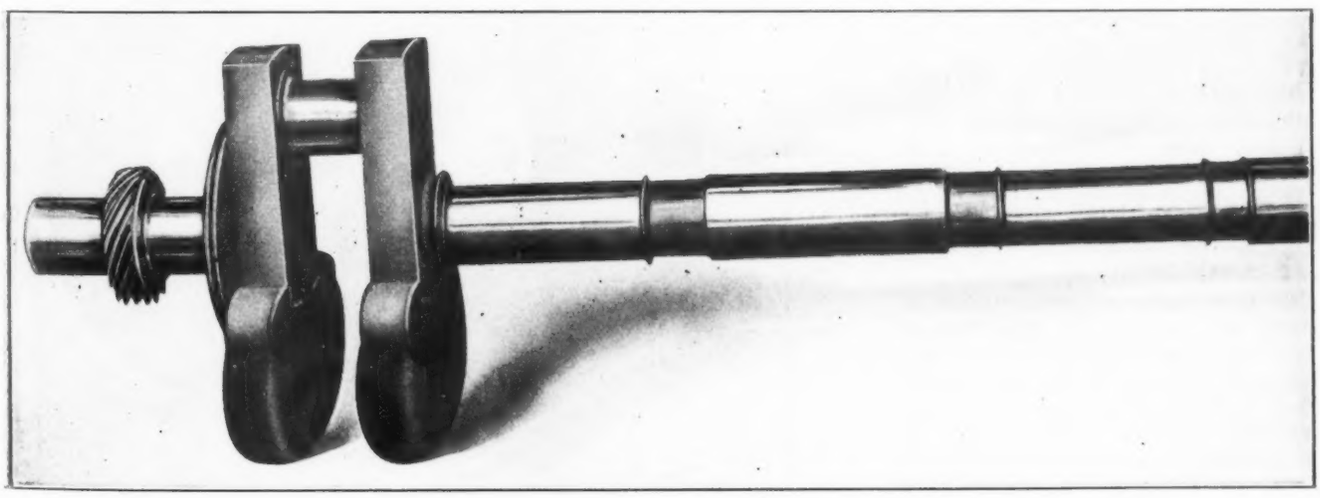


FIG. 6. CRANK SHAFT OF DU BOIS GAS ENGINE

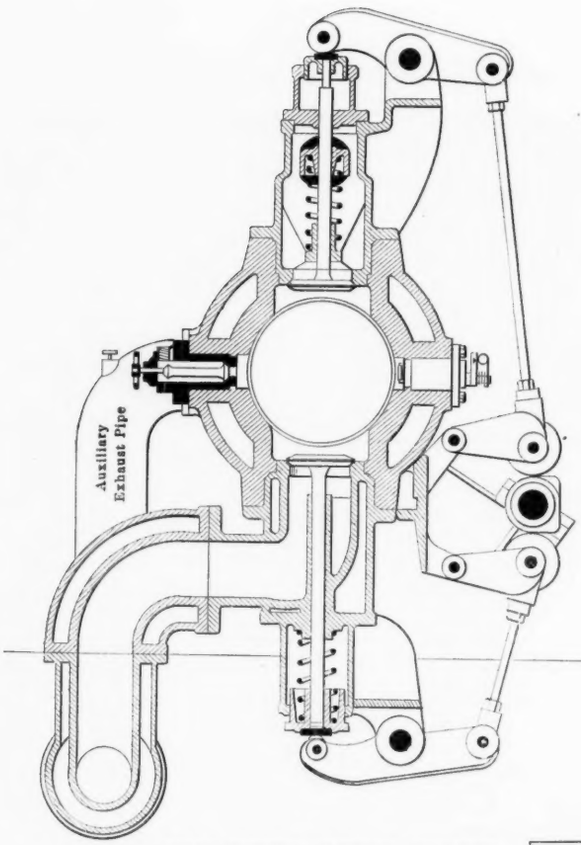


FIG. 7. CROSS SECTION THROUGH CYLINDER AND VALVE CHAMBERS

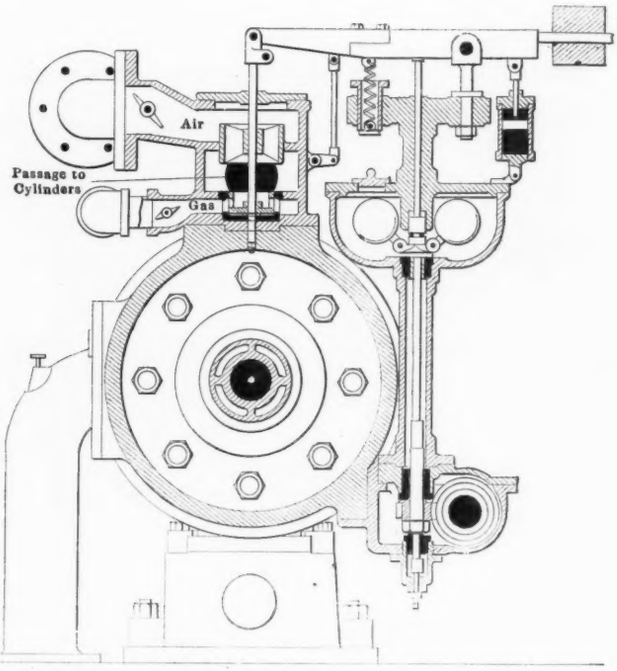


FIG. 8. CROSS SECTION THROUGH CYLINDER, MIXING-VALVE CHAMBER AND GOVERNOR

igniter rockers are mounted on these sleeves; turning the sleeves on the studs alters the relation between the rockers and the igniter triggers and thereby changes the timing. A handle at the middle of the reach rod serves for manipulating it and a clamp holds it wherever it is set.

General

The engine is arranged so as to be oiled by a central gravity-feed system. Since the piston trunks are more than full-stroke length, they always cover the oil holes in the cylinder walls; timed lubrication is therefore unnecessary. Fig. 10 shows the arrangements for leading oil to the main bearings and the crank pin.

The engine is equipped with a valve in the head of the rear cylinder for starting with compressed air, and the valve disk is located at the inner face of the cylinder head, so that when it is closed no pocket is formed in the combustion-chamber wall. This construction is shown in Fig. 4. The indicator openings are provided with similar valves, as shown in Fig. 7. This drawing also shows the unusual feature of a water-jacketed exhaust pipe with which every Du Bois engine is equipped. Another unusual feature, although not original on this engine, is the injection of cooling water into the exhaust pipe; this cools the exhaust gases so suddenly that a muffler is not required. The water jacket around the exhaust pipe

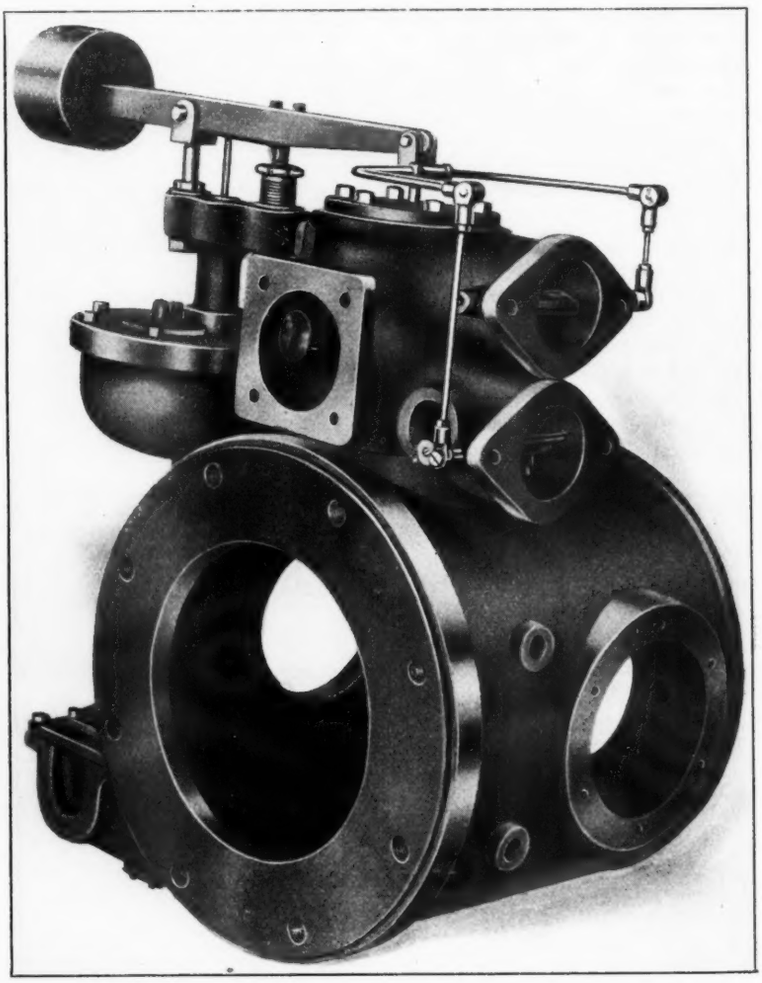


FIG. 9. GOVERNOR MECHANISM OF DU BOIS GAS ENGINE

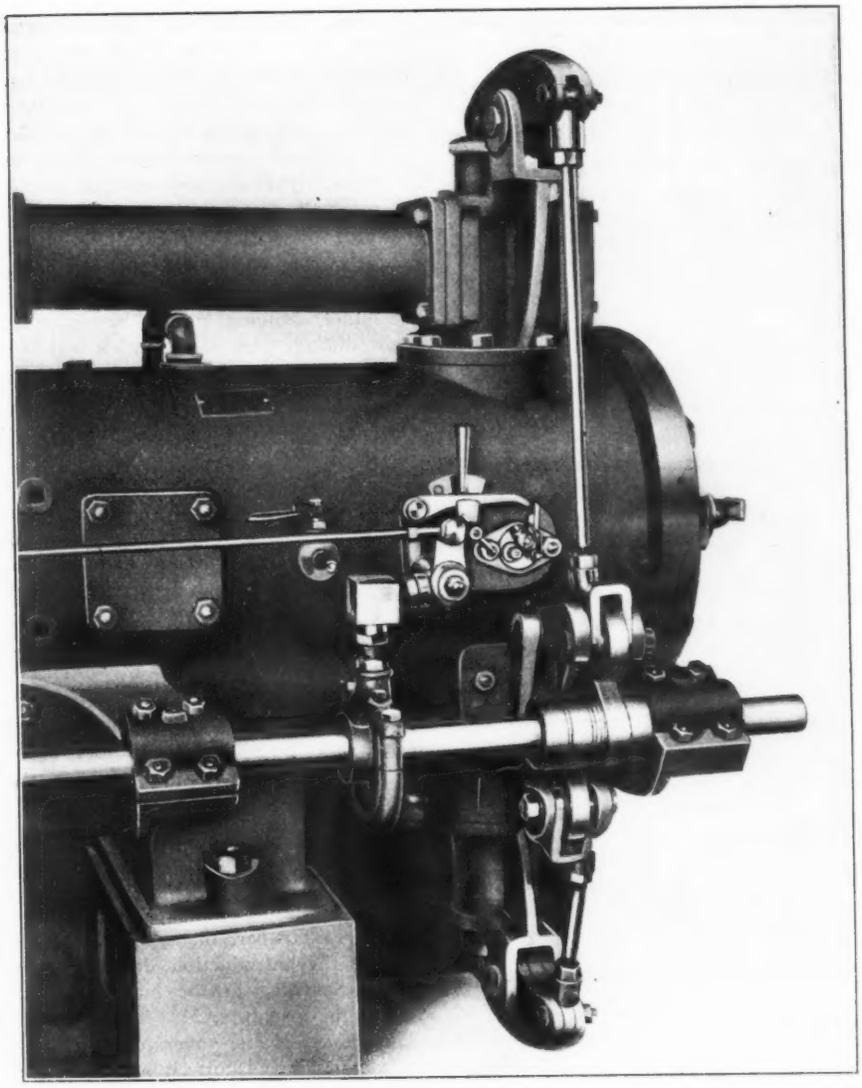


FIG. 11. DU BOIS IGNITER MECHANISM

is chiefly for the purpose of obviating the exposure of dangerously hot surfaces where attendants are likely to come in contact with them, although the water jacket also cools the exhaust gases considerably.

The compression pressure is about 140 pounds absolute for natural gas, and 180 pounds for producer gas, and the engine can be changed from the one to the other compression in a few minutes.

The engine runs very smoothly. The writer recently witnessed the starting up and operation of a twin-tandem engine and electric generator; within 55 seconds after the attendant turned on the lubricating-oil feed, which was the first move, the engine and generator were running at normal speed and ready for the load. Except for the clicking of the igniter triggers and the hum of the flywheel, the equipment ran noiselessly.

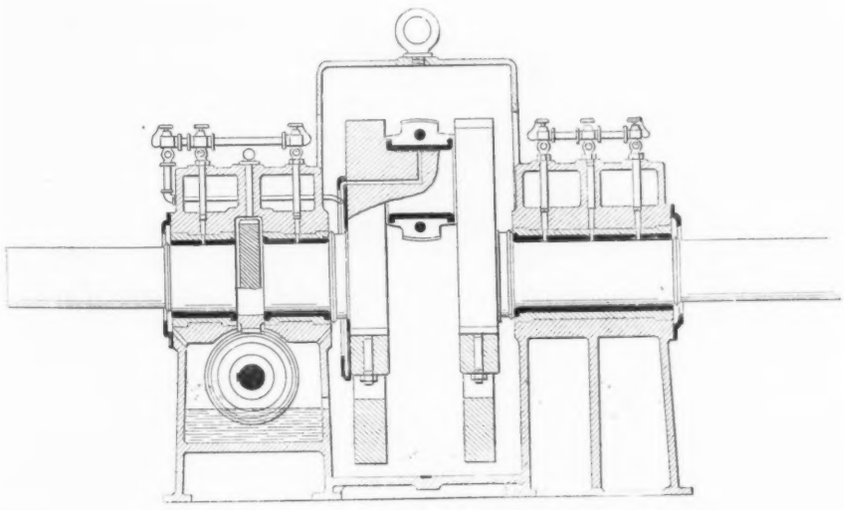


FIG. 10. MAIN SHAFT OF DU BOIS ENGINE IN ITS BEARINGS

A Plant Remodeled

By Charles A. Lower

In electric-light and power work, there are ever a multitude of problems for the engineer to contend with. There are the questions of economy, safety and, to the engineer most important of all, uninterrupted service. There are times when the engineer will sacrifice economy and take chances of a "calling" from the office; times when he and his men cast safety to the winds and risk life and limb for the all-important object of keeping the current on the line; but the most trying time to an engineer is when the plant has become overloaded to such an extent that the several units cannot be left idle for sufficient time to make needed repairs, when the capacity of the plant must be increased or the service suffer. Such was the condition when the writer took charge of the power house of the Richmond, Ind., Light, Heat and Power Company.

As shown by Fig. 1, the plant consisted of two 300-horsepower tandem-compound steam engines, one 250-horsepower twin tandem gas engine, two 150-kilowatt three-phase 60-cycle 2300-volt alternators and two 500-volt direct-current generators, one a 60-kilowatt machine and the other a 100-kilowatt generator.

The floor level of the steam-engine room was four feet lower than that of the gas-engine room, and this necessitated a great deal of step climbing. High water was a continual menace to the wheel pits of the steam engines, and the engines could only be kept running during high water by pumping out the pits. The long line of shafting in the plant put such a demand on the coal pile that it was decided to eliminate the shafting and belt directly to the generators. As the quantity of natural gas was failing, and the price per 1000 feet increasing so that the gas engine could no longer be operated economically, it was decided to abandon this unit and put in a 615-horsepower steam engine belted directly to a 300-kilowatt alternator. The 60-kilowatt direct-current generator was to give way to a 100-kilowatt direct-current generator, and in order that direct current might be furnished when the large engine and

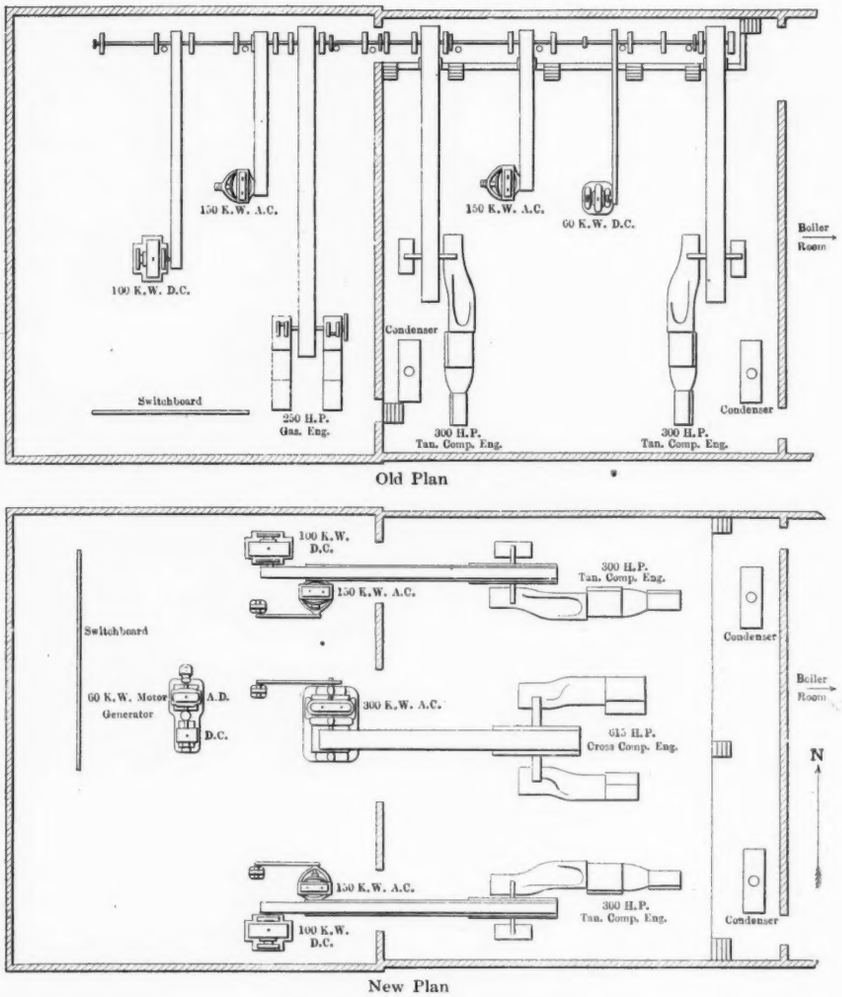


FIG. 1. OLD AND NEW ARRANGEMENT

generator only were running, a 60-kilowatt motor-generator set was installed.

As may be noted from a comparison of the two plans, only one piece of machinery, the condenser in the southeast corner, was left in its original position, but even this condenser had a new foundation placed under it. The floor level of the east room was raised so that the wheel pits would be above high water, and in order to throw the two rooms together, openings were cut in the wall and I-beams inserted.

After removing the gas engine, the large engine and generator were placed, but could not be belted up until the tandem engine farthest west was removed. A foundation was constructed for this engine to the south of the large engine.

The work of removal began at 12 p. m. on a Saturday night, and such rapid progress was made that the large engine was belted up and carrying the load at 6 p. m. Monday evening, the east engine having been able to care for the load in the meantime. The photograph, Fig. 2, shows the plant at this time. The west condenser was next moved to the northeast corner, and then the tandem engine on the south was belted up with the alternating-current and direct-current generators in tandem. After taking out the shafting, a large portion of the foundation on which it stood had to be removed to make room for the tandem engine, which was to be placed on the north side of the building. So hard was the concrete of this foundation that picking it out was found to be out of the question, and, although under protest from the manager, dynamite was resorted to. By keeping all doors and windows in the building open, and by carefully placing and covering each blast, the foundation was removed without a particle of injury to either building or machinery. The most difficult part of the work was now over, and the remaining tandem engine was soon in its new position.

As the 150-kilowatt alternating-current generators could not be run in parallel with the 300-kilowatt machine, which was not compensating, and as the exciters of the former were in bad condition, the compensating wiring was cut out and each machine excited by an independent exciter. After this, any two or all three generators could be operated successfully in parallel.

The job had been truly a trying one, but it gave some satisfaction to feel that it had been accomplished without injuring a man and without removing the current from the line.

In an article entitled "Parallel Operation of Alternating Current Generators," by H. R. Mason, on page 226 of the August 11 number, the type got twisted so that the introduction did not make sense. Speaking of the magnetic reaction of the armature, Mr. Mason wrote: "The same reaction operates to reduce the voltage on a short-circuit to a point which makes it impossible to maintain the destructive arc produced by direct-current short-circuits if the conductors are spaced more than an inch or two apart."

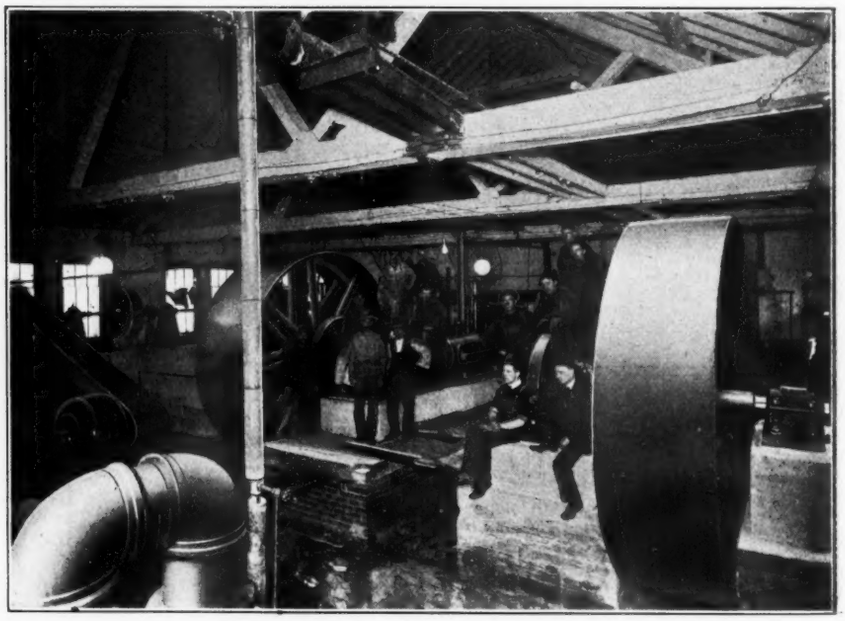


FIG. 2. REMODELING THE PLANT

Automatic Steam and Ammonia Packings*

Advantages, Cost and Application of Diagonal or Automatic Packing and a Brief Discussion of Packings for High Temperature and Ammonia

BY W. E. SANDERS

With increased competition among engine builders came a desire to reduce the friction of the engine to a minimum. Great attention was paid to bearings and bearing metals and to the friction developed at the crossheads. At last engine builders took up the question of friction in the stuffing box. To explain this it will be necessary to examine briefly the action of steam within a steam cylinder. A direct-acting steam pump, such as a boiler-feed pump, is working against a constant pressure throughout the whole stroke. As a result the steam is admitted at full steam pressure, and this same pressure is kept up throughout the whole stroke; necessarily the same grip must be kept on the rod throughout the entire stroke. But on the return stroke the steam is allowed to flow out easily from the cylinder and the pressure is merely nominal, possibly two to five pounds. During the working stroke the pressure is not only high but is uniform throughout. In almost all steam engines, however, it is different. When steam is exhausted from a steam pump at, say, 100 pounds pressure, it is at a loss, that is, the steam could do a great deal more work if it had a chance to do so.

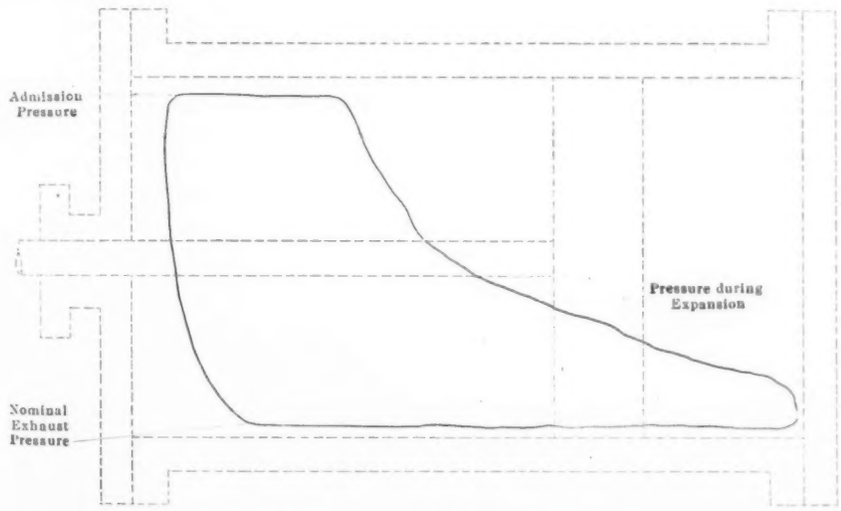


DIAGRAM OF PRESSURE IN ENGINE CYLINDER

But in an engine the energy is nearly all used up in the engine itself and the steam exhausted at a low pressure. This is done by admitting steam at a higher pressure than is necessary, but admitting it at this pressure for only, say, a third of the stroke. The surplus energy has been taken up by setting the flywheel in motion.

When the steam is no longer admitted, the pressure in the cylinder decreases. When this has become too low to do the work, the energy stored in the flywheel helps out and carries a part of the load through the rest of the stroke. When it leaves the cylinder the steam has given up most of its energy. This means that the pressure from within has ranged from full pressure down to a few pounds, at which it stands through the return stroke until compression begins.

Recalling the first principle of packing, that the grip on the rod must be proportional to the pressure from within, that is, the greater the pressure, the greater must be the grip, and the less the pressure, the less need be the grip, it will be seen that it is entirely unnecessary after steam has been cut off and during the return stroke to maintain the same grip on the rod as at first. But with all the classes of packing which we have so far discussed, the grip on the rod is the same throughout both strokes. If any packing could be devised, therefore, that would vary its grip on the rod with the pressure from within, it would manifestly be much more economical because it would save the work of driving the piston rod through the excess grip during expansion and the return stroke.

Diagonal Packing

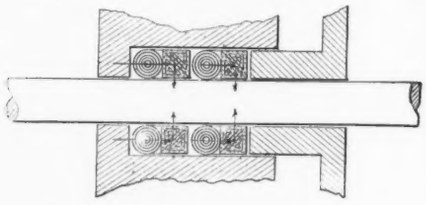
To secure this end, inventors began work about 1880 and a short time later produced a diagonal packing. This and similar packings are called "diagonal" packings. A much better term is "automatic" packings, and so we call them, since they are truly automatic, the grip on the rod varying automatically with the pressure from within the cylinder.

Of these diagonal packings, the simplest consists of a cushion made of flax or made of round duck, and this flax or duck is wrapped up in a braided sheath together with two wedges, the wedges being in cross-section right-angled triangles. These wedges were originally made by splitting a coil of hydraulic packing diagonally, and thus obtained the name "diagonal." If this packing is placed in the stuffing box so that the cushion is next to the cylinder and the wedge that touches the cushion is next to the rod, an automatic form of packing will be obtained. Of course, the first tendency of the pressure from within is to blow the whole packing out. This it cannot do because the gland is in the way. As the pressure strikes the cushion, the cushion is pressed against the wedge next to it, and as this wedge cannot go farther, it is pushed sidewise, sliding on the other wedge, and this motion will be toward the piston rod. As the pressure within the cylinder is increased, the pressure of the wedge against the rod must be increased. As the pressure from within the cylinder diminishes, the grip of the wedge upon the rod also diminishes. Thus the packing has the tightest grip on the rod when the steam is admitted to the cylinder at full pressure.

When the steam is cut off and expansion in the cylinder takes place, the pressure in the cylinder decreases and the grip on the rod must also decrease. When the exhaust stroke comes and the pressure of the steam within the cylinder is merely nominal, the grip on the rod is merely nominal, and a great saving is effected. Carefully conducted tests show that the friction caused by the stuffing box and bearings, when a gum-core packing or a packing of the monkey-wrench class is used, amounts to about 9 per cent. of the total power of the engine; in the case of an expansion packing it amounts to about 7 per cent. of the total load, and with a diagonal packing the friction is only 3½ to 4 per cent.

*Copyrighted, 1908, by W. E. Sanders.

When this is figured to dollars and cents, the loss will be appreciated. The cost of one horsepower per year in a cheap and crude engine will amount to about $55 or $60. For the best uptodate engines of large plants, this can be reduced to about $30 per horsepower per year. If we take as a conservative average $40



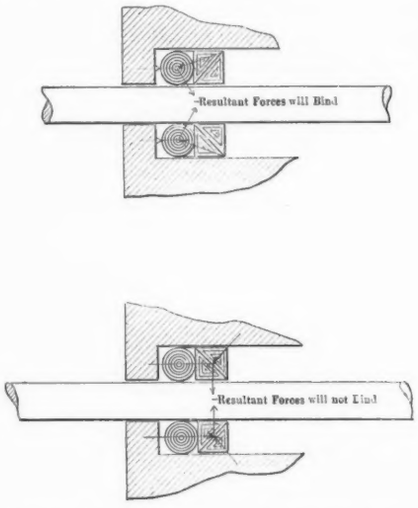
DIAGONAL OR AUTOMATIC PACKING

per horsepower per year, it can be seen that with a 100-horsepower engine a saving of five horsepower, or $200 per year, can be effected by using a diagonal packing instead of a monkey-wrench packing, and a saving of three horsepower, or $120 per year, by using a diagonal packing instead of an expansion packing. This would take place in the saving of steam, and as coal is necessary to generate steam, the saving would appear in the cost of coal.

Diagonal packing is without doubt the most economical of any form of fibrous packing, the saving being in the amount of steam used and also in the wear on the rod, less coal being needed for steady running and fewer repairs because of worn rods. It is absolutely necessary that this packing be placed properly in position. The cushion must be next to the cylinder or bottom of the box, for this is the direction from which the pressure comes. It is equally important that the wedge that is next to the cushion be also next to the rod. A crude illustration will explain this:

If you were to clamber down a narrow well, you would place your feet out against the wall, and your weight from the center would force your feet out against the wall, giving you a tight grip. Now, if the wedge which touches the cushion should be next to the wall of the stuffing box, the sliding of that cushion would be toward the wall of the box, and the reaction would force the cushion against the rod, binding on the rod and increasing the friction rather than diminishing it. If the packing is inserted in this way, it is almost certain to fail. On the other hand, if you should step into a wedge-shaped trench, you know that the more you press down the tighter your foot is wedged in, and the wedging motion is always sidewise. When the wedge nearest the cushion is next to the rod, its motion is directly sidewise toward the rod, with the result that an increased pressure produces an increased grip on the rod, but does not bind, and when inserted this way, the packing will in all probability be perfectly satisfactory.

Within the last few years an improvement in this packing has been made, not in principle, but in construction—an improvement that has lengthened the life of the packing from two to five times. Until lately all diagonal wedges have been made by splitting a coil of hydraulic or of duck packing diagonally. This gives a wedge in the form of a right-angled triangle with the long plies on one side, but becoming narrower, until at the tip they become a sixteenth of an inch wide and are held on by rubber friction alone. This is the weak point, for here the rod working back and forth wears or rubs off the narrow ply. When this is gone, the empty space gives a chance for the next ply to work loose, and the result is a speedy and complete breaking up of the packing. The improved wedge is made of one ply wrapped about itself and molded into shape. This overcomes the defect of weakness at the tip and makes it possible to use the packing three or four times longer than the older style.



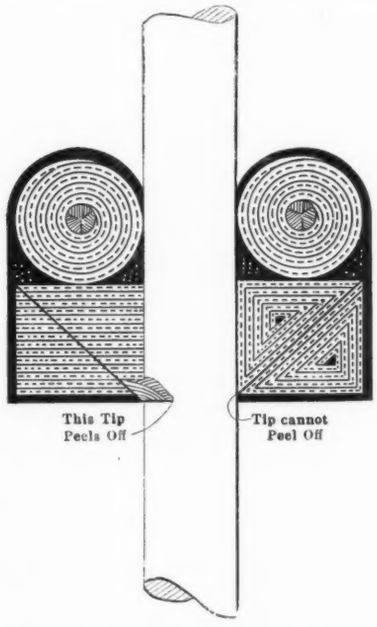
THE DIFFERENCE BETWEEN BINDING AND WEDGING

Diagonal packing is the most economical and at the same time the most sensitive packing. Ninety-nine per cent. of the failures of this packing are due to its abuse with a wrench. It should fit easily into the box. If it seems too thick, do not try to jam it in, but with a flat board press it against the rod or tap it slightly. This will force the wedges down and make the packing thinner. A sixteenth of an inch can be gained in this way. Then insert the packing in the box, and when it is full, use the gland as a ram to force the packing in snugly, but do not hammer it in. Then bring up the nuts with the thumb and forefinger only.

High Temperature Packings

Superheated steam is fast bringing about a change in the materials used in the construction of packing, and if all engines used superheated steam there would be a revolution in packing materials. All of the packing so far described is made chiefly of rubber and cotton, but rubber is of vegetable origin and so is cotton, and vegetable materials have a limit to the temperature which they can stand. When rubber is subjected to high temperature, it will begin to break down, losing first its elasticity, and secondly, it will burn. If air cannot come to it freely, it chars, and this is just what happens with packing containing rubber. If the temperature becomes too high, either because the temperature of the steam is too high or sufficient friction develops to raise the temperature, it will first lose its elasticity and become "dead," and next it will char and would burst into flame could air get to it. The same process takes place with the cotton fabric, and although the steps are not so marked, yet the final result is a charred fiber. The packing is then said to be "burnt out."

In the stuffing box the temperature is not as high as the temperature of the live steam, because the outside of the box is exposed to the air, and more than this, the rod during one-half of its stroke is exposed to the air. The temperature of the packing is then considerably less than that of the steam, and rubber packings can be used even with superheated steam if the resultant temperature in the stuffing box is sufficiently low. The temperature of the packing may be raised by the temperature of the steam, and more frequently by the forcing down of the gland, thus pressing the packing too tightly



OLD AND IMPROVED FORMS OF DIAGONAL PACKING

against the rod and increasing the temperature by the friction. This factor is dependent almost entirely upon the skill of the engineer. A good engineer can use a poor packing and make it last a long time, while a poor engineer can ruin the best of packing in a couple of hours. It is the writer's custom to refrain from

the use of rubber when 160 pounds pressure is used, or rather at a temperature corresponding to 160 pounds pressure.

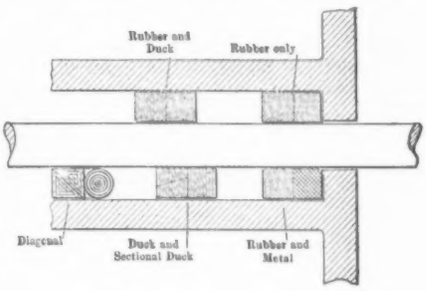
Many plants today are run on pressures over 175 pounds, making it necessary to use a packing made of some material which is not affected by the heat, and for this packing manufacturers use asbestos. Asbestos is an inorganic mineral fiber which is spun into threads and from these a cloth is woven, which cloth is frictioned with a water-resisting compound. Were there no such compound present, the moisture which might reach the asbestos would soak up and separate the fibers, just as water will soak up into a blotting paper, and the asbestos cloth would lose its strength and go to pieces. When it is covered with a compound, the water cannot reach the fibers directly, and no breaking up can take place. For sheet packing, it is customary to spin the fibers of asbestos about a wire, forming a thread with a wire core. This gives a strength which cannot otherwise be obtained, and for all gasket work, wire-inserted asbestos cloth is used.

Rod packing usually comes in one of two forms: A square packing, which is generally made up of plies of asbestos sheet folded back and forth upon themselves with a rectangular rubber cushion, the whole being surrounded by several plies of asbestos sheet. As the asbestos acts as a nonconductor of heat, the rubber is to a certain extent protected and exerts an elastic-cushion effect. This asbestos sheet may or may not have a wire insertion. Generally speaking, it is better not to introduce the wire, since it is not really necessary and there is the possibility of cutting or scoring the rod. The second form is made up round, either by rolling up the asbestos around a core made of rubber or around some other core, such as flax. Some engineers prefer the round form and others prefer the square. As a matter of fact, after being used for some time the round form becomes square, so that it really does not make very much difference.

This packing does not enjoy the advantage of being automatic. It is in principle rather poor, belonging to the first class, but it is absolutely necessary because the materials employed must be able to withstand high temperature.

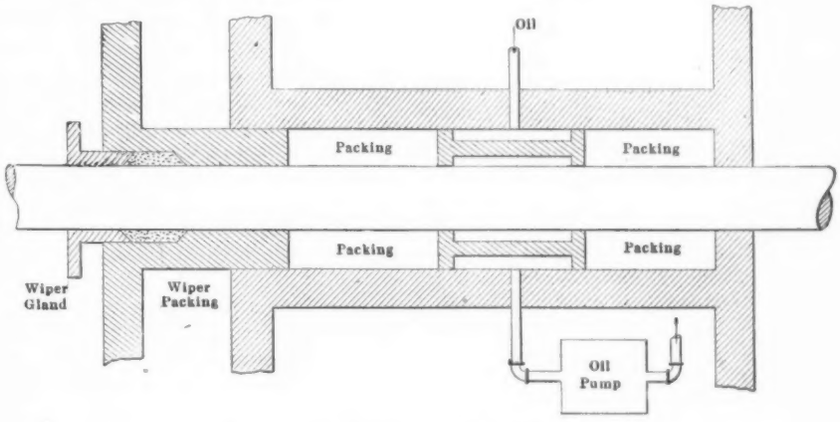
Ammonia Packing

Ammonia is more difficult to pack than steam, not because it is harder to hold back ammonia than steam, but because a loss of ammonia means a greater loss of money, and the ammonia is quite offensive. As a result, it is demanded that ammonia be packed tighter and more surely than steam. The problem is still further complicated by the fact that there are so many different kinds of machines. The use of ammonia for cooling purposes is not as old as the use of steam for power, but there are many machines now in use which are old and improperly made. More than this, the conditions may change very rapidly. One minute the temperature of the stuffing box may be 10 degrees below freezing, and shortly afterward it may rise to 300 or 400 degrees above. When the packing is warm, the rubber will expand and pack satisfactorily, but when the rubber is cold, it contracts and unless the gland be adjusted quickly, ammonia will leak, and, if adjusted for low temperature and a sudden high temperature appears, the rubber will expand and press against the rod with unnecessary force, producing friction which raises the temperature high enough to burn out the packing. A good engineer must adjust the gland and the expansion valve at the same time, that is, adjust the gland to take care of immediate conditions and the expansion valve so as to change these conditions. If less cooling is called for in the cooling coils, there is a possibility of a "freeze-back" and the cylinder of the compressor becomes very cold. The expansion valve must then be adjusted and at the same time the gland must be adjusted to compress the packing. As soon as conditions become normal, the cylinder will become warm and the gland must be slacked off to release the pressure on the rod.

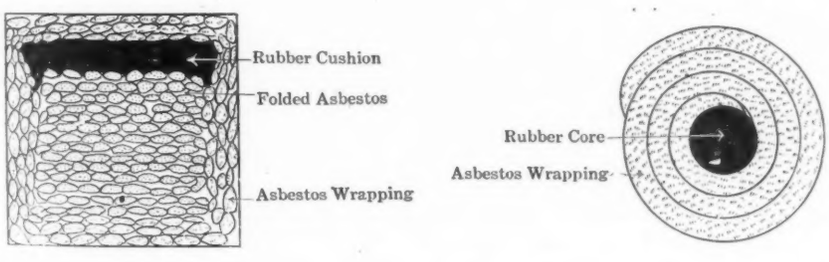


DIFFERENT COMBINATIONS OF PACKING USED WITH AMMONIA

On an ice machine the construction of the stuffing box is peculiar. As a rule it consists of three sections, the end sections being separated by a separator, spool or lantern, which occupies the middle section of the box. Through this middle section a current of oil is kept passing as a means of lubrication. It is difficult to recommend any particular form of packing for ice machines, for so much depends upon the individual taste of the engineer. Some engineers will pack with a pure rubber ring entirely. Others will use rubber and metal packing alternately. Others will use rubber and ordinary duck expansion packing alternately. Still others use an expansion ring and a sectional ring so as to secure a quick adjustment. A great many use a diagonal packing with excellent results. What one engineer can use successfully will be of no use to another engineer, although a skilful engineer will use any of these packings with success. The great objection to many of them is that the loose fibers, which become detached by the action of the rod or of the oil, manage to get into the oil wells or small pipes



AMMONIA-COMPRESSOR STUFFING BOX



FORMS OF HIGH-TEMPERATURE ASBESTOS PACKING

through which the oil passes, and clogging these up, will prevent the flow of oil and consequent lubrication.

The gaskets used on a refrigerating system must be exceptionally good and elastic and must withstand the action of ammonia. The tendency of the ammonia is to soften and swell the rubber, and if portions of this gasket become detached in the pipe, they may go through and clog the expansion valve and cause trouble. A proper rubber compound is far more successful than pure rubber. Some designers have constructed flange joints made in such a way that the rubber can hardly come in direct contact with the ammonia. The extreme changes of temperature in a cooling system make it necessary to have an elastic gasket, or to allow means for contraction and expansion by loops in the line or expansion joints.

The Purchase of Electric Motors and Accessories

By Howard S. Knowlton

The purchase of one or more electric motors for a power installation demands a wide range of judgment. In too many cases the matter is settled in an off-hand way, mainly upon the strength of the lowest price or the promptest delivery, without giving enough consideration to the detail features of the design. In buying motors for work that involves no new conditions, and which is largely in the nature of a replacement of worn-out equipment, the amount of investigation which it will pay to make of the motor designs is much smaller than in cases where the results are somewhat uncertain. No single motor will, as a rule, have all the advantages of design, and the larger the list of competitors, the more important it is to weigh the merits of each thoroughly.

Very careful consideration should be given when possible to the character of the work which a motor is expected to perform, and also to the conditions surrounding the location of the installation. In making up specifications for bidders to use, the limits of duty and voltage which the motor is liable to be called upon to meet should, if possible, be clearly stated, and if the purchaser has in mind the type, horsepower and speed range necessary, these should be stated. Some latitude for the manufacturer is desirable, unless the purchaser is willing to go to the expense of buying specially designed motors. The special machine means a longer time before delivery can be had, and in general a higher cost to the buyer per unit of output. As far as practicable, therefore, it is well to stick to so-called standard motors, except in cases where a special design is really necessary. If there were no special designs, however, there would be little progress in motor construction, and the amount of special designing which the engineering departments of the manufacturing companies are doing month after month in the motor field shows that the problem of machine driving is still unsolved in many details as regards industries which have only lately taken up electricity in the place of older and less efficient means of power transmission and conversion.

If the horsepower of a motor is not specified by the purchaser, nor the speed and winding particulars, the responsibility of the manufacturer should be clearly defined, and the capacity and temperature guarantees stated in the final contract. Of course it is not necessary to write long specifications for motors that are to be used for work in which others of the same character have been entirely satisfactory; in such cases a simple written order will usually satisfy all the engineering requirements. When tests are specially required for settling the adaptability of a given motor for a certain service, it is well for the contract to include a clause allowing the purchaser or his authorized representative to witness both the shop construction and such final tests as are necessary to prove the motor from the shop point of view. Ordinarily, it will not be necessary for the purchaser to visit the factory during the construction of motors; the manufacturer's certified test will be enough in the way of advance data. But in cases where the service conditions are untried or specially difficult the broadest coöperation is desirable between the engineers of the purchaser and the manufacturer.

General Construction

Covers for motors of the inclosed type should make dust-proof joints with the frame, and ought to be provided with fastenings of a substantial design, capable of holding the covers securely to the frame under all conditions, with special regard to loosening or displacement by vibration. Armature shafts should be strong enough to resist appreciable bending under the worst possible conditions of overload; they should have ample bearing surface and be efficiently lubricated by automatic oiling rings. The bearings should be provided with either babbitted or solid bronze linings, or others of equal capacity, and the oil rings should be turned true and free from all defects. Points of this nature should be looked out for on inspections, as well as borne in mind in roughing out general specifications. The design of the successful motor should in some way provide for the prevention of oil running along the shaft. Oil wells are desirable if provided with outlets at least ¼ inch in diameter, which will prevent their being filled beyond a suitable point and will allow any excess to flow out. All motors should be provided with name plates giving the name of the manufacturer, shop number, type and class, winding, voltage, amperes, horsepower rating, and revolutions per minute at rated load. This practice is generally followed by the principal manufacturers, but in some cases one still finds a lack of complete data on motor name plates.

The design of field-magnet coils should be such that all magnet poles will be equally magnetized. The windings should be protected from mechanical injury, and if possible should be coated with a material not affected by water or grease. No permanent external resistance should be used in the field-winding circuits of any motor. Armatures are preferably of the slotted-core type, built up of thin disks of soft steel of the best quality, preferably having the slots between the teeth punched out of each disk separately, not milled in the core after assembly. Insulation between the disks is essential to minimum losses. In general the armature coils should be form-wound and easily removable, but in very small motors, say below 5 horsepower, hand-wound coils are usually not objectionable. The coils should be retained in the slots of the armature body by wedges of maple or other suitable material running the full length of the armature, or by some equally satisfactory method. Armatures ought to be electrically and mechanically balanced. Commutator segments are most satisfactory if composed of pure, hard-drawn copper, the segments being of liberal depth and insulated from each other and the shell by pure mica of such hardness as to secure even wear with the copper.

Special attention needs to be given to the selection of brushes in order that their material may be homogeneous and the quality such as to give perfect commutation without cutting, smearing, or scratching the commutator bars. The brush-holders should be readily accessible for adjustment and the renewal of brushes and springs, and of strong, substantial construction. The brush-holder springs should not be depended upon to carry the current; it is a good plan to use flexible connectors on the brushes of motors carrying more than 15 or 20 amperes, unless the brushes are rigidly fastened to the holders by screws or wedges. The brush-holders ought to be separately adjustable for tension, and on the larger sizes, say above 5 horsepower, should be adjustable preferably without the use of tools, and simultaneously adjustable for position. The brush-holders of a reversible motor should be of a design to permit of the rotation of the armature in either direction without shifting or changing the brushes, and for motors operating in only one direction it is desirable that the holders be so constructed that by very slight changes in the relative position of their parts the motor may be operated in the reverse direction. The angle of the brush to the commutator should

not change appreciably as the brush wears down, and the position of the rocker arm for sparkless commutation should be plainly marked.

Motor frames are preferably of steel, but allowably of a high grade of cast iron, with bored seats if the magnet poles are bolted to the frame. The base should be planed true, to give a firm contact surface with its support. The frame ought to be neatly finished and to be provided with an eye or ring bolt of ample size and strength to permit lifting the complete motor by it.

Before a motor is accepted, if tests are made of it, it is desirable to consider the following points: Adjustment and fit of parts, mechanical strength of parts against breaking or displacement, balance of armature, sparking at commutator, variation of speed under different loads and temperatures, insulation, heating, noise, efficiency and lubrication. The materials and workmanship of all parts should be of the best possible quality, and the base, bearings, armature, shaft, field magnet and other main parts should not spring under the application of any reasonable force. A good way to test the ability to resist centrifugal force is to run the armatures of shunt-wound motors without load for half an hour at double their rated speed, and armatures of series motors at four times their rated speed for the same period, provided this does not involve a peripheral velocity of over 6000 feet per minute, in which case the test may be made at the latter speed. The perfection of balance can be tested by running the motor at normal speed, at which it should not show the slightest vibration. Variable-speed motors should run without vibration at all speeds, and undue noise should not be noted in any type of motor. In a good motor it will not be necessary to shift the brushes between no load and normal load in order to prevent sparking. Oil wells should be of ample capacity, and oil rings should run freely to lubricate the bearings. When test records are supplied by the manufacturer in place of tests by the purchaser, it is desirable to have full information regarding the motor, including the readings taken on the heat run and the hot and cold resistances of the windings, as well as the temperatures at which these readings are taken. When complete, such readings give the time at which they were taken, voltage, total amperes, amperes in shunt-field winding, voltage at shunt field-winding terminals, room temperature, and revolutions per minute.

Auxiliary Equipment

The selection of a controlling panel is an important part of motor buying in many cases. In general a first-class controlling panel will consist of a suitable insulating slab, finished in black polish or marbleized, carrying a double-pole main-line knife switch with inclosed indicating fuses, a starting lever and contacts, overhead magnetic release, and the necessary resistance mounted at the back. On panels where speed control by field resistance is required, suitable rheostat connections should be provided, giving an ample number of steps to secure smooth control and accurate adjustment, and provision should be made so that a motor will not start on a weak field. For motors requiring large starting currents, say more than 50 amperes, the starting lever should not be relied upon to carry the current in the running position. It is poor practice to leave the starting resistance in series with the field winding in the running position, although some of the best-known motor starters are so built. The connections should be such that there will be no disruptive discharge of the field on opening the circuit, either by opening the main-line switch or by forcing the starting lever to the "off" position, and it should not be possible to apply full voltage to the field winding when the starting lever is in the "off" position. Care should be taken to see that there is no interference between operating parts, such as the line switch when opened and the starting-lever arm. All magnet coils and all contact parts carrying currents should be renewable from the face of the panel without disturbing any of the rear connections. It is desirable to have the panel mounted on a rigid metal-box frame, with the sides of perforated metal extending the length and breadth of the slate to protect the connections and parts back of the panel, and suitable lugs or extensions ought to be provided for the support of the frame, except in cases of special design. Preferably no part of the face of the panel should project from the edge of the frame.

Automatic no-voltage release mechanisms should either bring the starting lever to the "off" position or open a circuit-breaker upon any failure of the voltage. The winding of the no-voltage release magnet should not be put in series with either the field winding or the armature resistance. The automatic overload-release magnet should be of the nature of an ordinary spring-operated circuit-breaker, having the release mechanism operated by a positive hammer blow, delivered by a core or armature moved against the influence of gravity; it should have its own independent contacts for opening the armature circuit, and should open the circuit in case of overload under any conditions, for example, during ordinary running, during the act of starting the motor, or if the starting lever should become stuck on any starting point and the current then switched on from the outside. For motors requiring, say, 50 amperes or less, the overload release may be of the interlocking type, in which case it should be so interconnected with the starting lever that it cannot be closed with the latter in any but the "off" position. For motors of larger output, a single- or double-pole circuit-breaker, entirely separate from the starting lever, must be used, and if it is a double-pole circuit-breaker with independent-line contacts the line switch may be omitted. An overload device which operates by short-circuiting or opening the circuit of the retaining magnet of the no-voltage release is undesirable. Overload devices should be provided with renewable arcing contacts of carbon, adjustable and provided with a scale graduated from normal current to 100 per cent. overload, to facilitate adjustment to the desired number of amperes, and to be able to carry continuously a current of about 50 per cent. in excess of the rated full-load motor current without undue heating. The tripping device should be able to withstand severe jarring without opening.

Insulating materials used on panels should be noncombustible, nonabsorbent, and not susceptible of damage by moisture or moderate heating. It is desirable that terminals be marked with a designating letter indicating the connections to be made, and preferable that all connections shall be near the edge of the panel to avoid crossing the face of the latter; in general, the line terminals should be at the top of the panel and the others at the bottom. For motors of, say, 50 or 75 amperes capacity, the terminals can be of the square-block type, consisting of a brass block with a hole drilled through its longer axis and provided with set screws to hold the wire in place. On larger panels suitable lugs are essential for connection.

All windings of cutoff magnets should preferably be run through an insulating varnish during winding and the outside surfaces of the coils well varnished and taped. All resistance coils and connecting wires should be of noncombustible material and capable of carrying full-load current continuously. Resistances should be mounted at the back of the panel upon the supporting frame and not directly upon the panel, all coils being directly protected from moisture and so inclosed as to be protected from chips and metal filings. Springs should be strong enough to work quickly and prevent sticking after the contacts have become worn or roughened. All contacts should be easily renewable, and sliding brushes are preferably of the self-adjusting type, easily renewable and able to ride over projections standing, say, 1/16 inch above the contact plates. Rugged design of all operating parts is desirable.

In cases where it is necessary to install drum-type controllers on account of the exposed location of the mechanism, each terminal can profitably be marked with a designating letter or number showing what lead is to be connected to it. Roughening or burning of contacts is not to be tolerated under normal conditions of service. All arc-rupturing contacts should be of simple construction and easily re-

movable, so that they can be quickly replaced when worn out. A controller used in a busy plant may save its excess cost many times over if the contacts can be quickly renewed, in comparison with a less expensixe outfit which has not this advantage. The loss that may be entailed by delaying the operation of a heavy crane controller in a large foundry during the busy time of the day justifies the purchase of the best controller on the market. All sliding contacts should have ample surface for the current to be carried and should make good contact at all points. The construction should be such that no part of the contact can be crippled when the controller is turned quickly on or off. Controller fingers are preferably capable of adjustment as to alinement and spring tension, and means should be provided to retain the operating lever at various positions with accuracy.

The Prevention of Steam Engine Breakdowns

By H. S. Knowlton

The study of steam-engine accidents is always a valuable means of improving operating conditions, if the causes of breakdown are definitely ascertained. The steam engine is one of the most reliable machines known to modern industry, but unless it receives skilful designing attention, first-class workmanship in the shop, careful erection, and intelligent inspection in operation, continuous service cannot be expected for long periods. Volumes have been written upon steam-engine design, and there is no lack of matter written for the guidance of the operating engineer, but in the actual field of engine service, it is the breakdown that tells the story of where the design should be improved, or where the methods of operation can be bettered. The following notes have been prepared from the reports of one of the large casualty companies, in the hope that the examples of failure selected are sufficiently representative to point the way toward improvements in operation that will result in a reduction of the number of breakdowns due on the whole to preventable causes:

Breakage of Piston Rods

One frequent cause of engine failures is the breakage of piston rods and air-pump rods at the cotter holes. In nearly every case of breakage, where the mean unit stress obtained by dividing the load upon the rod by its net cross-sectional area in square inches is low, it has been found that a crack starting from the corners of the cotter hole on one side of the rod *A A*, Fig. 1, and extending into the latter, has existed for some time previous to the final failure. As the stresses required to break wrought iron and steel are much higher than the mean stresses to which such rods are usually subjected, the breakages are attributed to unequal distribution of the load over the cross-section of the rods, and to its concentration upon the outer surface of the section at the edges of the cotter holes. This

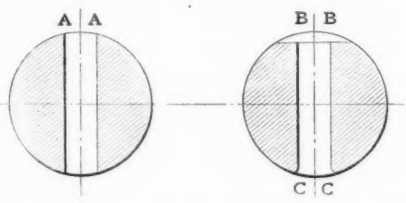


FIG. 1. COTTER HOLE IN PISTON ROD

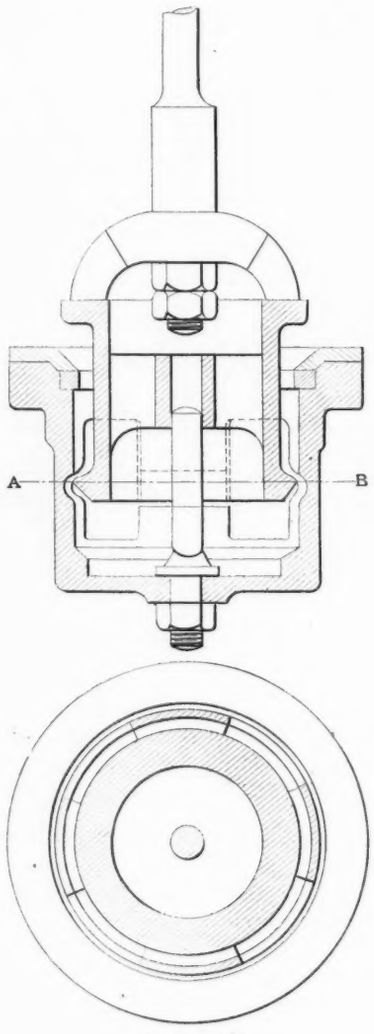


FIG. 2. EMERGENCY VALVE OF TURBINE

concentration of stress can very easily be brought about by driving a cotter having a taper differing slightly from that of the cotter hole. It can also be caused by using too weak a cotter. When a cotter is bent, the pressure becomes concentrated at the edges of the cotter hole at the intersection of the circular arcs defining the circumference of the rod with the vertical line defining the cotter hole, where there is almost no sectional area to resist it. Consequently a crack is started which gradually extends inward until the rod gives way. Remedies for this weakness are to flatten the rod where the cotter hole is cut, *B B*, Fig. 1, and to round the edges of the cotter hole, *C C*, Fig. 1.

Inefficient Lubrication

The effect of inefficient lubrication is well illustrated in the case of a tandem-compound 13x23x30-inch engine, which had a normal speed of 91 revolutions per minute, with a boiler pressure of 110 pounds. Both cylinders had slide valves, and the high-pressure had cutoff valves in addition. The cast-iron lever on the rocking shaft for working the high-pressure main valve was broken, also the expansion-valve spindle, and the main valve spindle was bent. When the valve-chest cover was taken off, the expansion valve was found broken in pieces, the faces of the main valve deeply scored, and the cylinder face plowed up to a depth of about ¾ inch. The face had originally been 1 inch thick, but was reduced to 3/16 inch. The socket and gland in which the main valve spindle worked were similarly worn, as well as the main valve spindle itself. When the engine was examined after breakdown the valves and valve chest were found to be covered with a charred deposit, and it was learned that the owners had begun to use superheated steam about three weeks before, apparently on their own responsibility, without any thermometer to show the steam temperature, any special arrangement for lubricating the slide valves, or care to ascertain the effects of high temperature upon the working parts exposed to it.

A Case of Grinding

In the practice of the casualty company upon which these notes are based, an interesting case of grinding under the action of flowing steam occurred in a 100-kilowatt steam turbine running at 3000 revolutions per minute, with a boiler pressure of 140 pounds per square inch. The turbine was equipped with an emergency valve, Fig. 2, which was closed by a special governor in case of excessive speed. This was double beat, of cast iron and 4 inches in diameter. It worked on a cast-iron cylindrical seating about 3/32 inch larger in diameter than the valve itself, with mitered facings at top and bottom forming seats, and with ports in the cylindrical surface through which the steam coming from the boiler passed to the turbine when the valve was lifted off its seats. The valve had a bridge over the top, with a hole in the center by which it was hung from the valve spindle, and was centered with the seats by a vertical pin standing upward from the bottom of the casing.

Upon hearing an unusual noise, the engineer in charge of the turbine stopped it and took out the valve. He found the cylindrical distance piece between the two seatings cut through and broken, and the vertical pin was also broken off near the bottom. It appeared that the steam passing through the valve had set up vibration, which had broken the pin and left the valve free to swing against the cylindrical surface containing the ports. It had also caused the swinging valve to rotate, for the surface was cut all around with a circumferential groove at the level of the lower face of the valve. On opening up a similar turbine the emergency valve and seating were found to be in the same condition.

Increasing Steam Pressure to Meet the Load

The effect of gradually increasing the steam pressure, as the duties of the plant became more and more arduous, is shown in the case of two 20x40x60-inch cross-compound engines, with Corliss valves on the high-pressure cylinders, and on the low-pressures, a slide valve at each end. When the engines were first insured, they indicated 640 horsepower, with a boiler pressure of 100 pounds per square inch. The load was increased to 740 horsepower, and the pressure to 110 pounds per square inch, and one result of the increased load was to raise the pressure in the valve chest of the low-pressure cylinders to 25 pounds above atmospheric. After a time both doors of this valve chest were found to be cracked, Fig. 3, and the cause was attributed to excessive pressure, for on the day before the

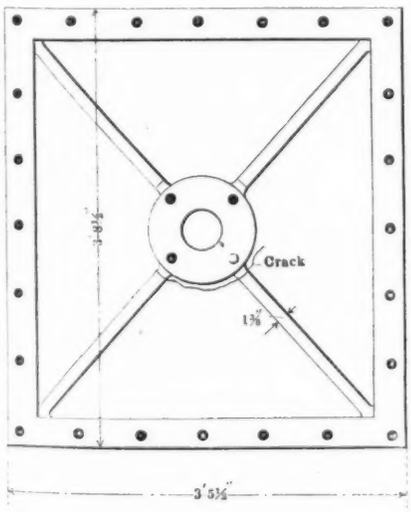


FIG. 3. VALVE-CHEST COVER

cracks were discovered, the eccentric which operated the low-pressure valves had slipped, and as the relief valve on the chest was small and loaded to only 40 pounds per square inch, even this pressure may have been considerably exceeded. It was thought by the company's experts that the ordinary working pressure of 25 pounds may have been enough to cause the covers to pant, and the effect of this would probably in time break the ribs. The ribs were on the outside of this engine, instead of on the inside, as they should be. Ribs placed on the outside add little to the strength of the flat surfaces, for with the pressure inside the passage the maximum tensile stress is at the outside edges of the ribs. The top of the passage is like a cast-iron I-beam with no bottom flange.

Flooding the Cylinders

An instructive accident happened to an engine connected to a barometric condenser. The exhaust pipe of the engine discharged into a hot well. The injection water was supplied by a centrifugal pump driven from the engine by counter-shafting, and the quantity was controlled by raising or lowering an annular valve located at the mouth of the injection pipe. The foot of the tail pipe was submerged in a tank from which an overflow pipe was led back to the source from which the water was taken, and the latter pipe also received the discharge from the condenser of another engine. Two breakdowns occurred, in both of which the cylinders were damaged by water. The engine was running under very light or practically no load at both times. The speed of the centrifugal pump had been increased a short time before the first breakdown from 1070 to 1220 revolutions per minute, the lower speed being just sufficient to lift the water to the condenser, and with the increase in speed the vacuum went down from 24 inches to 15 inches.

In seeking the cause of the trouble, the engineer of the casualty company had a piece of the condenser exhaust pipe removed and the engine was run noncondensing, so that the centrifugal pump could run at its proper speed. The supposition was that the pressure on the top of the water-supply pipe was sufficient to force a certain quantity of water upward past the outside of the annular valve, with a velocity which would carry it around the bend of the condenser-exhaust pipe, down into the hot well, overflowing the latter and backing up into the cylinder. It was found that when the annular valve stood 3 inches above its seating, sufficient water entered the condenser to raise the water level up to the top of the valve. When the opening was reduced to 2⅜ inches the water level fell a little, and at 1⅞ inches the water began to squirt up between the upper edge of the valve and the condenser. With the valve 1½ inches off its seating the flow became great enough to follow the bend of the exhaust pipe and pour out of its mouth. It was clear that this overflow had condensed the steam and caused the trouble, and the experiment emphasized the importance of skilled attendance in the operation of centrifugal pumps in connection with barometric condensers.

When the vacuum goes down, the water supply should not be increased without making certain that the pump is not already lifting more than the condenser can discharge. A careful watch should be kept on the initial and final temperatures

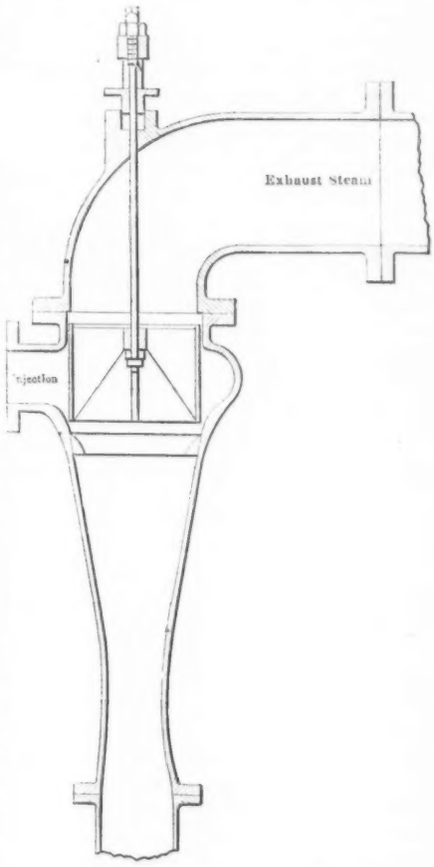


FIG. 4. BAROMETRIC CONDENSER

of the water. A vacuum breaker or relief valve of the automatic type, arranged to come into action when the water rises above a certain level in the condenser, is a safeguard, but careful operation shuts the injection valve before stopping the engine, and stops the engine before stopping the air pump. Failure to stop the engine first, in one case, resulted in the injection water, which should have been carried away by the air pump, filling the condenser and exhaust pipe and overflowing into the cylinders, breaking cylinders, piston rods, crosshead and guide.

The Detroit Edison Company has completed its plans for the duplication, at a cost of $2,000,000, of its present power plant. Foundations for the addition were laid last fall.

To temporarily patch a leaky pipe, bind around it some sheet packing, secured with stout, pliable wire. If any clamps are handy, they will help out.

The Plunger Hydraulic Elevator

Construction of Passenger Elevators of This Type; Details of the Cylinder and Valves; How Weight of Plunger Is Counterbalanced

BY WILLIAM BAXTER, JR.

What is commonly known as a plunger elevator is a direct-acting machine in which the lifting plunger is located under the center of the elevator car and attached directly to it. The plunger works in a cylinder sunk into the earth to a depth somewhat greater than the rise of the elevator. When water is forced into the cylinder, the plunger rises and pushes the car upward. To make the downward trip the water is permitted to escape gradually from the cylinder, allowing the plunger to descend under the influence of gravity.

For many years this type of elevator has been used for short travels, but within the last ten or twelve years it has gradually come into use for higher rises, and at the present time is used in buildings where the rise is as great as 300 feet. As the elevator car can rise only as high as the plunger travels, it follows that when the rise is 300 feet, the cylinder must extend down into the earth several feet more than 300, because when the car is at the top of the elevator well the bottom end of the plunger must be some distance below the top end of the cylinder. Furthermore, it is necessary to provide sufficient length of plunger to carry the car a short distance above the upper floor, say, two feet, in order to avoid running the bottom of the plunger too high up in the cylinder if the elevator should overrun the upper limit of travel.

As a plunger elevator is a direct-acting machine, the diameter of the plunger need not be large, unless very low pressure is used. As a rule the plungers are made of 6-inch steel piping, which, when finished, has an external diameter of 6½ inches. The cylinder is also made of steel pipes, and of a diameter generally about two inches greater than that of the plunger. This diameter may be reduced for elevators of small rise and slow speed, but for high lifts and high speeds it is greater, as it is necessary to provide sufficient space between the plunger and the cylinder to permit the water to pass down when the plunger ascends without absorbing too much power by its friction against the walls of the cylinder and the plunger.

The plunger passes through a stuffing box at the upper end of the cylinder, and is provided with guide shoes at the lower end to keep it in line and central. The well in the ground in which the cylinder is set is made about three or four inches larger than the outside of the cylinder. Any portion of it that passes through gravel or clay is lined with a retaining casing, but portions that run through rock are not lined. The space between the cylinder and the sides of the well is filled in with sand.

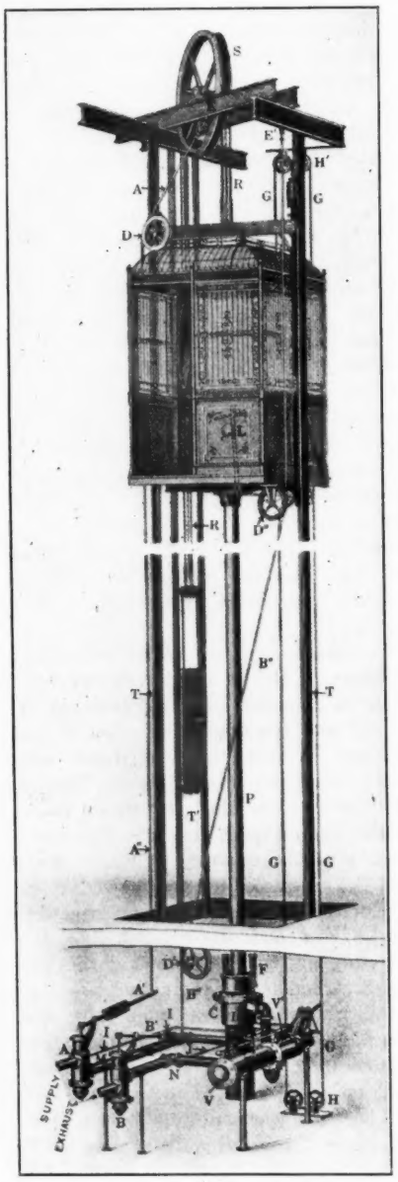


FIG. 245. PLUNGER PASSENGER ELEVATOR

Construction of the Passenger Elevator

The construction and general arrangement of a first-class passenger elevator of the plunger type are indicated by Fig. 245, which is an elevation of the Otis machine. This illustration is broken at a point between the elevator car and the bottom of the elevator shaft in order to reduce its length, but the part broken away would only show the continuation of the guides, plunger, operating ropes, etc.; all the operating parts of the outfit are shown in the illustration. The car rests upon the upper end of the plunger *P*, and the latter runs down into the cylinder *C*, the upper end of which projects above the ground floor. From the top of the car a number of ropes *R* extend upward and over a sheave *S* and thence down to a counterbalance *W*. This counterbalance serves to reduce the pressure required to raise the elevator, and also to reduce the compression stress to which the plunger is subjected.

The pipe of which the plunger is made weighs about 22 pounds per foot, so that a plunger 200 feet long will weigh about 4400 pounds; this is more than the car is likely to weigh, the latter ranging between 3000 and 4000 pounds. If the car weighs, say, 3600 pounds, and the plunger 4400 pounds, the two combined will weigh 8000 pounds, and with no counterbalance this weight would have to be raised in addition to the load. Consequently the plunger would be subjected to a compression stress of 3600 pounds plus the load at the upper end, and 8000 pounds plus the load at the bottom, the stress increasing from top downward at the rate of 22 pounds per foot. With a counterbalance weighing, say, 5000 pounds, the weight raised will be reduced to 3000 pounds plus the load, and as the counterbalance exceeds the weight of the car by 1400 pounds, it will actually hold up about one third of the plunger, from the upper end downward, when the car is empty.

When the car is at the bottom of the shaft the plunger is immersed in the water in the cylinder, consequently a portion of its weight is balanced by the water it displaces. When the car is at the top of the shaft the plunger is out in the air and its weight is not counterbalanced to any extent by the water. This being the case, the weight lifted will be less when the car is at the bottom of its travel than when at the top, the difference being equal to the weight of water displaced by the plunger. By properly porportioning the weight of the ropes *R*, the load lifted can

be made equal at all points, for when the car is at the bottom of the shaft these ropes will hang above the car, and thus will offset a portion of the counterbalance W, while when the car is at the top of the shaft the ropes will hang above the counterbalance W and balance a portion of the weight of the car.

The main valve for controlling the movement of the car is shown at V, and

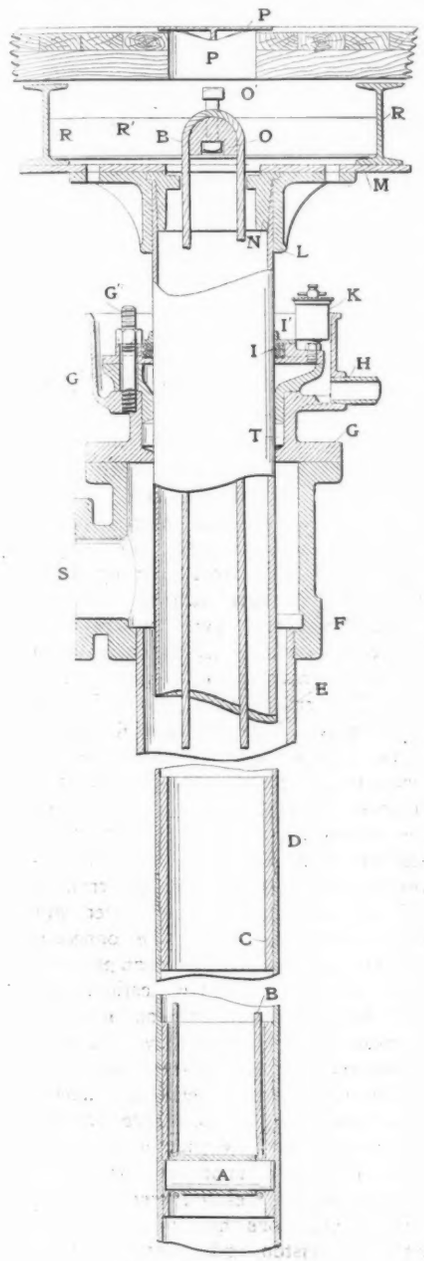


FIG. 246.

the pilot valve at V'. The two valves A and B are the automatic stop or limit valves, A being the top limit and B the bottom. The valve A is actuated by the rope A'' which pulls up the lever A' and thereby closes the valve. This rope moves the lever A' through the motion of the elevator car. Looking at the illustration, it will be seen that the rope A'' runs over a sheave D mounted on top of the elevator car, and it can also be seen that when the car approaches the upper limit of travel, D begins to put a bend in A'' and thereby draws up the lever A'; by the time the car reaches the upper floor, A' will be raised enough to close the valve A. By this arrangement the valve is closed gradually and the car is as gradually brought to a state of rest.

The valve B is actuated by the rope B'' in precisely the same manner that A is operated by the rope A''. The rope B'' passes over the stationary sheave D' and under the sheave D'' located under the car, and when the latter descends near enough to the lower floor, the bend put in the rope B'' by the sheave D'' will raise the lever B' and gradually close the valve B.

The pressure water enters through the valve A; hence, at the top landing the automatic stop arrests the movement of the car by shutting off the supply water. When the elevator car descends, the discharge water passes out through the valve B; hence, the bottom limit valve stops the descent of the car by stopping the escape of water from the cylinder.

Construction of Cylinder

The construction of the upper end of the cylinder is shown in Fig. 246. This drawing, which is a vertical sectional elevation of the top of the cylinder and plunger, also shows the way in which the plunger is fastened to the under side of the car, as well as the construction of the plunger. For the purpose of re-inforcing the plunger, a steel cable B is strung inside, both of its ends fastened to a pin A, located some distance below the center of the plunger, and the loop or bight, at the top of the plunger, is passed around a tightening block O; this block is arranged so as to be drawn up by the bolts O' to put the desired tension on the rope B. The plunger D is made of as many lengths of piping of the proper size as may be necessary, these being connected by means of long internal sleeves C. The plunger sections are turned true and highly polished, and the screw threads at the ends are made with great accuracy, so as to hold the sections in perfect alinement when connected. The threads are also made extra long, so that the joints may be as strong as the other parts of the pipe. For the purpose of making the pipe sections come together perfectly central when joined, the center portion of the sleeve is turned true, and the ends of the pipe are bored to fit this portion; when the parts are screwed up, the turned central portion of the sleeve slides into the bored-out ends of the pipes and brings them into line, so that there is no point around the joint where one part projects over the other.

The top of the cylinder is finished off with a casting F screwed to the top of the upper section of the cylinder barrel E. On top of the cylinder cap F is mounted a stuffing box casting G, containing the usual packing space T and fitted with a compressing gland G'; the latter is constructed so as to form a space surrounding the plunger to hold oil, the latter being fed in from an oil cup K. Above this oil reservoir is a recess in which babbitt wiping rings I are placed for the purpose of scraping the oil off the plunger as it moves upward, and retaining it in the space in the gland G'.

In Fig. 245 it will be noticed that buffers F are provided for the car to rest upon when at the lower floor. Similar buffers are also provided for the counterbalance W to rest on, to prevent running the car up against the overhead beams. The construction of the car buffers is

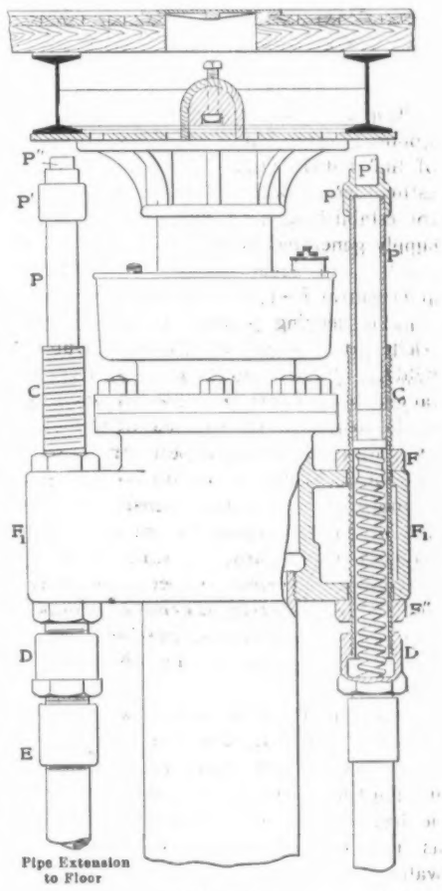


FIG. 247.

shown in Fig. 247, which is an external view of the upper end of the cylinder taken at right angles to Fig. 246. The buffer consists of a plunger P made of pipe, provided with a cast cap P' and a rubber cushion P''. The plunger P slides within a cylinder C, also made of pipe. Within this cylinder there is a spring that is compressed by the plunger, the lower end of the latter being provided with a flat head to press against the top of the spring. The cylinder C is held in position by a side extension F, formed on the top cylinder casting F. The nuts F' F'' are screwed on the cylinder C, the latter being threaded, and by this means the hight of the buffer is adjusted. To furnish additional support, so that the buffer

may not be pushed down and the thread of the nut F' stripped if the car should come down unusually hard, a pipe extension E is provided, extending down to the floor, or some other firm support. These buffers are set so as to be struck and compressed every time the car comes down to the lower floor. acting to stop the motion gradually. If the car descends at the normal speed, the buffer is compressed slightly, just a trifle more than is necessary to hold the unbalanced portion of the weight of the car, but if the car speed in approaching the floor is excessive, the buffers will be compressed farther, and the car will run a few inches below the floor.

Electricity from Peat *

"Consul General Robert J. Wynne, of London, reports that before a committee of the British House of Commons interesting details were given of the scheme for establishing in Ireland a new electric supply generated by peat gas—the first of the kind in Great Britain. The Dublin and Central Ireland Electric Power Company is seeking powers to supply electricity to portions of Counties Dublin, Kildare, Queen's and King's, and have arranged to purchase 500 acres of peat bog in the district. Hitherto one of the chief objections to the use of peat for generating power is that it contains 90 per cent. of moisture, and is too expensive to dry; the promotors propose to use a process, common in Germany, by which it is advantageous to retain 50 per cent. moisture in peat, thereby obtaining by-products, such as sulphate of ammonia, which would pay the cost of the peat."—*Consular Report.*

This report needs some explanation. Dr. A. Frank, of Charlottenburg, Germany, has in recent years made extensive investigations on peat as a source of gas; he has reached the conclusion that peat as fuel, on account of its 90 per cent. of water, cannot be transported on a commercial scale; he argues, therefore, that industries should be carried to the peat bogs just as they are to waterfalls, or, that the peat bogs be used for the generation of electricity, as are the waterfalls, including our great Niagara.

After many experiments and tests at Stockton and Winnington, Scotland, the German Mond Gas and By-products Company was organized in 1907. A demonstration plant was immediately erected, in which any owner of a peat bog could have tests made. Soon two other plants, one in Scotland and the other in Italy, were built, each at first with a daily capacity of 100 tons of dry peat. The success of these led to the building of a third plant, now under construction in Ireland, on a larger scale, while in Germany three others are projected.

As stated above, the great advantage of this process is that peat containing 50 per cent. water can be used, and in the raw, or unmachined condition, only needing to be plowed or and dried on the open bog without other handling. On account of the somewhat complicated gas-making machinery, and the recovery of the by-products, the process is only profitable for large plants having at least a capacity of 100 tons of dry peat per day, or the equivalent of about 500 cubic yards of raw peat.

*By Julian Bordollo, in the *Journal* of the American Peat Society.

Gas Compressors of Special Type

By Silas R. Stone

Gas compressors are of the same general design as air compressors, the principal differences being those required by the composition and cleanliness of the gas, which often prohibits the use of certain materials or methods in construction. In the following will be found described an interesting type built for special service.

Not long ago exhaustive tests were made, by a prospective user, of a large number of different types of compressor. These tests led to the conclusion that for gas compression the design shown in the accompanying illustration would give exceptionally good results. The company having control of the patents covering the essential features of the design received orders for three large compressors, each with a capacity of 4200 cubic feet of gas per minute against a pressure of 30 pounds per square inch, and the builder was required to guarantee a specified high efficiency.

Each machine consists of a duplex gas compressor, with gas cylinders 30 inches in diameter and a 36-inch stroke, driven by a horizontal cross-compound noncondensing engine having cylinders 22 and 30 inches in diameter and a 36-inch stroke. The normal speed is 62 revolutions per minute, with a steam pressure of 125 pounds per square inch at the engine. The high- and low-pressure steam cylinders are both provided with a complete Corliss valve gear, and so connected that in case of necessity either side may be run alone.

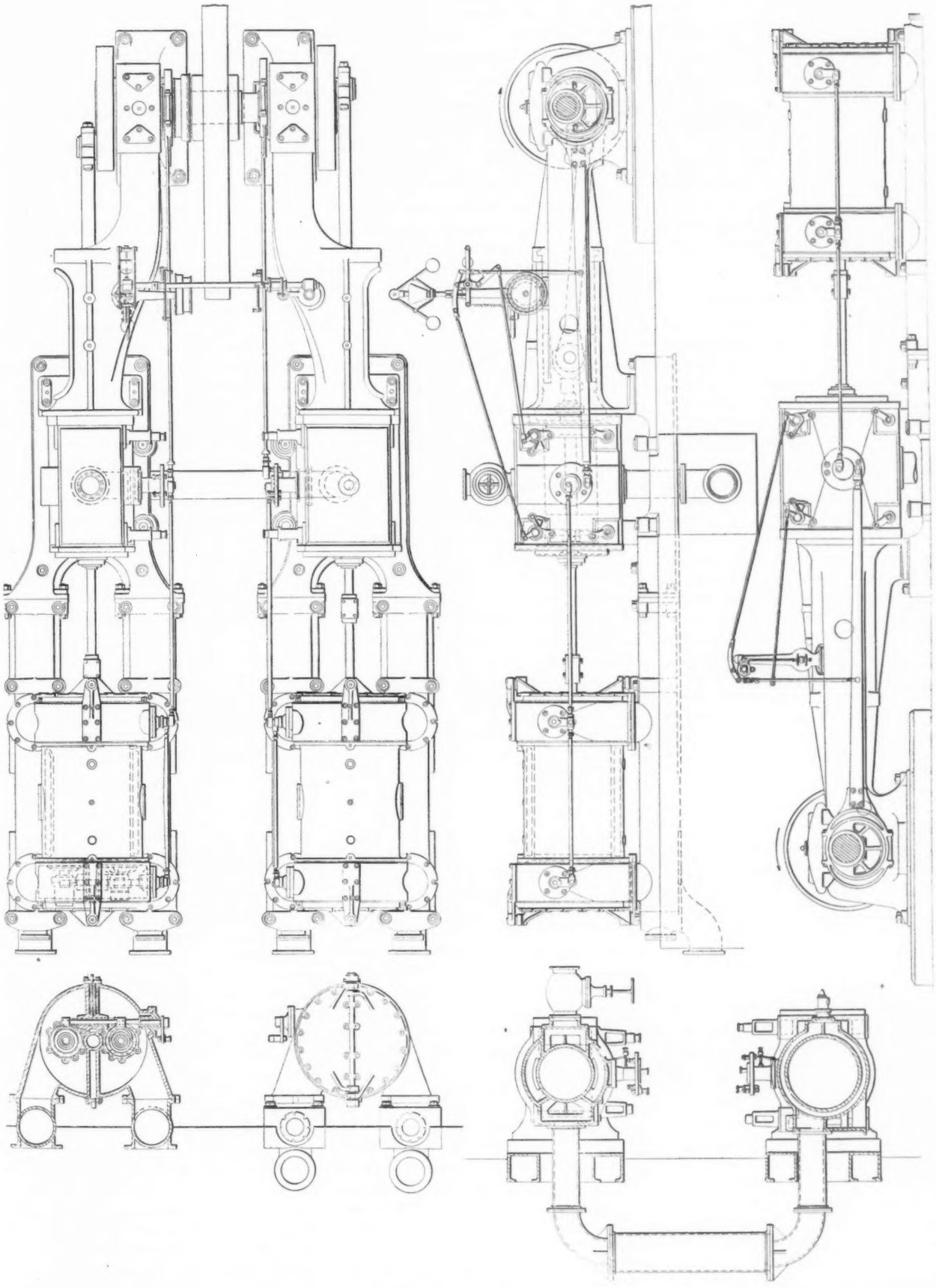
The two water-jacketed gas cylinders are placed tandem with and behind the steam cylinders, and are connected to the steam cylinders by means of a heavy cast-iron bedplate extending under both steam and gas cylinders, one side of which is made to act as a suction pipe and the other as a discharge pipe for the gas cylinders. The cylinder heads are designed so that the chambers are each divided into two compartments, one containing the suction and the other the discharge valves. As far as possible each head is jacketed except in the space between the suction and discharge sides, so as to prevent heating of the suction gas. The heads are also provided with doors attached to the cylinder by means of swing bolts and having hinges so that they can be easily opened and the valves exposed for examination.

By means of spindles extending into and through the cylinder heads, the gas valves are mechanically operated. There are one suction and one discharge valve at each end of the cylinder, and these valves are turned out of solid forgings and fitted with cushions. They can be lubricated from the outside, and special precautions have been taken to prevent the valves clogging, due to deposits from the gas. The gas-valve gear receives its motion from the steam wristplates. All valve rods are provided with right- and left-hand threads and with adjustable brass heads. The valve stems passing into the cylinder heads are fitted with valve forks which close the valve. The valves open automatically, but are controlled by this mechanical device.

The engine frames are of the regular Chalmers compressor type provided with extra-heavy bearings especially designed for gas-compressor work. Each is made in one piece, and cast with large feet or bases. The pillow block portions of the frames include main bearings fitted with adjustable quarter boxes suitably lined. The cover of each pillow block has an extra large chamber for containing lubricant. The crank shaft is an open-hearth steel forging. There are two disk cranks of the balance type, bored to press fit, forced on the ends of the crank shaft by hydraulic pressure and securely keyed. The crosshead ends of the connecting rods are made solid and fitted with adjustable brass boxes, while the crank-pin ends are of the marine type fitted with babbitt-lined brass boxes. The connecting rods are open-hearth steel forgings.

The crossheads are steel castings, provided with adjustable cast-iron shoes, the crosshead pins being held by a taper fit and secured in place by steel nuts. The flywheel is 13 feet 6 inches in diameter and of such weight as to insure true and even running at a low number of revolutions. The engine piston rods are held in the crossheads by pressed screw joints, and in the steam pistons they are held by lock nuts. The piston rods extend through the back head of the steam cylinders and connect with the gas piston rods, the connection being made by means of threaded couplings, in halves, to allow of proper adjustment of the clearance.

The steam pistons are of the same general design as the "Sweet" piston, i.e., a body fastened to the piston rod with a bull ring held in place by a follower and two packing rings, split, and pressed against the walls of the cylinder by steel springs. The governor of this engine is fitted with levers for full-stroke cutoff



SPECIAL TYPE OF GAS-COMPRESSOR UNIT BUILT BY THE ALLIS-CHALMERS COMPANY

gear, so that the engine can cut off as late as three-fourths stroke. On the low-pressure side a cutoff column is connected up to the governor, so that in case of running the low-pressure side alone it will still work under governor control.

Nineteen additional units of the same type were afterward ordered, making in all twenty-two of these gas compressors thus far erected and in operation in this plant. The Allis-Chalmers Company, of Milwaukee, is the builder of the machines.

Liquid Fuel

By Charles L. Hubbard

The object of this article is to give a brief review of the subject rather than to take up in detail any particular branch or present the results of any single test; and is especially for those who wish for a general knowledge of the matter for purposes of comparison without going too much into the details. The data presented represent average rather than specific conditions and results.

Advantages and Disadvantages

Taking up briefly the advantages and disadvantages of liquid fuel as compared with coal, we may mention among the former absence of ashes and soot, cleaner heating surfaces, a more even distribution of heat in the combustion chamber, as it is not necessary to open the feed doors to supply fresh fuel, and an increased steaming capacity of the boilers due to the above conditions. It might be mentioned here, however, that the recent improvements in mechanical stokers tend to secure the above results in the case of coal also, but the greater simplicity of the apparatus required in oil burning, together with the absence of dust, ashes and clinkers and the ease of handling, are still important factors in favor of oil.

The disadvantages include danger of explosion under certain conditions, noise from the burners if not properly designed and adjusted, and higher cost, except in or comparatively near to the sections where oil is produced.

Heating Value 50 Per Cent. Greater than Coal

The two kinds of oil in general use are the crude petroleum as it comes from the wells, and the residuum remaining after the lighter products have been removed by distillation. The combustion of one pound of petroleum will produce on an average from 17,000 to 20,000 heat units, as against 12,000 to 14,000 for the same weight of coal, thus making its heating value, pound for pound, about 50 per cent. greater. Under the conditions of actual practice this difference is somewhat greater, and it is customary to consider 3½ to 4½ barrels of oil containing 42 gallons each, as equivalent to a ton of coal (2000 pounds). With these data at hand as a basis, the relative costs of the two fuels can be easily approximated for any locality by making due allowance for the reduced cost of labor in the case of oil.

Oil Burners

In burning oil, it must first be changed to a vapor, then mixed with air in the right proportion, and combustion must take place in a furnace in which a suitable temperature is maintained. The foundation of a method of oil burning depends upon: First, means for vaporizing the oil; second, an adequate supply of air delivered in such a manner as to be thoroughly mixed with the oil vapor in the right proportions, and third, provision for properly heating the oil and air either before mixing or immediately afterward as it is fed into the furnace. Although there are many forms of burners in common use, they may be divided into three general classes as follows: Mechanical spray burners, air burners, and steam-jet burners. In the first the oil is forced through a specially designed nozzle under a high pressure and is delivered to the furnace in the form of a fine spray which renders it easily inflammable. In the Körting burner the oil is passed at a temperature of about 270 degrees and a pressure of 50 pounds per square inch through a nozzle containing a specially grooved spindle; the effect of this is to give the oil a rotary motion, which breaks it into a spray as it leaves the nozzle. Another form of this type of burner causes the oil to pass through a small orifice against a cutter placed a short distance in front of it, the effect being similar in this case to the one already described.

In the air burners, so called, the oil is held in suspension and driven into the furnace by means of a jet of compressed air. Steam-jet burners act in a similar manner to those in which compressed air is used; the oil being injected in the form of a spray, a jet of steam being employed for this purpose instead of compressed air. Air in the right proportion is mixed with the oil and steam by means of an opening in the side of the burner and also by way of openings from the ash pit into the furnace. The use of compressed air and steam in a burner is much the same, but the air should first be heated to a high temperature by passing it through a fire-brick duct passing along the side of the furnace or combustion chamber.

In the Grundell-Tucker air burner, both the air and oil are supplied under a pressure of about 30 pounds per square inch. The oil is ordinarily heated by a steam coil to a temperature of 120 to 130 degrees, and the air to about 350 degrees. The high temperature of the latter is due in part to mechanical compression and partly to the absorption of heat while passing through the air chamber surrounding the burner.

The Williams burner is a representative of the steam-jet type. In this, the steam and oil are supplied through separate openings meeting at the end of a conical spindle placed at the center of the steam-delivery tube. Heated air is admitted through a third opening placed just beyond the spindle. Valves are provided for regulating the flow of steam, oil and air, and the mixture is blown into the furnace in the right proportion for combustion. For securing the best results with burners of this type, steam at a high pressure is desirable. Steam-jet burners spread the flame more and are thus more desirable for large furnaces with much exposed brickwork.

With air burners the flame is more concentrated and therefore more destructive to the boiler plates and setting. The best number of burners depends upon the size of the boiler.

They are commonly made in various sizes up to 300 horsepower or more, but several burners of smaller size are found to be more economical in the use of oil than a single large one. Common practice calls for one burner for each 60 to 80 horsepower under ordinary conditions. Another way to determine the number of burners is to place one in the center of each fire door. The arrangement of the furnace and its general construction depends largely upon the make of boiler and type of burner to be employed. The usual method is to cover the grates with brickwork, keeping them and the furnace walls in a state of incandescence by spraying them with the burning oil. Broken fire brick are commonly used for covering the grates, being spread over them in the form of a porous bed for admitting an abundance of air for combustion. The grates should be of ample size and air may be admitted by way of the ash pit in the usual manner.

A bridgewall is provided in the same manner as for a coal-burning furnace. Sometimes the grates are plastered over with a layer of fire brick laid in plastic asbestos, and air admitted from below through special openings of 70 to 80 square inches for each 50-horsepower burner. Where this arrangement is used, a spatter wall, so called, built up of fire brick is placed in front of the bridgewall and the flame from the burners directed against it. In some cases special burners are attached directly to the grates without change.

Care should always be taken to keep the direct flame away from the plates, as they are liable to damage from burning. Various arrangements are used for the storage of oil, the most approved being an underground tank of plate steel or iron located outside of the boiler room.

Temperature, Pressure and Inflammability

The oil should be kept warm in order that it may flow more readily through the pipes leading to the burners. If a pump is used, a coil may be placed in the tank, through which exhaust steam may be passed. Sometimes the oil is forced to the burners by admitting steam or compressed air to the upper part of the storage tank. If the former is used, it serves also to warm the oil. Hot water from the boilers is also used for this purpose in some cases.

For the best results the pressure of oil at the burners should be kept constant. This may be done by first pumping it to a standpipe and allowing it to flow to the

burners under a constant head due to its elevation, or it may be supplied directly by a pump provided with a relief valve and bypass so arranged that the pressure in the delivery pipe will remain constant. In case a standpipe is used, an automatic valve should be provided for draining it when the steam pressure drops below a given point in order to prevent flooding the burners when the pressure is not sufficient to atomize the oil.

Oil used for fuel is not of itself easily inflammable, but when heated much above 140 degrees, gives off gases which, if mixed with air in the proper proportion, are highly explosive. For this reason the storage tank should be located well away from the boilers and the heat of the sun. Gases may also be formed if air is forced through the oil, or if it is violently agitated, as by passing it continuously through a pump where the discharge from a relief valve is connected directly into the suction pipe. When proper precautions are taken, there should be no danger from explosion, and the element of danger need not be seriously considered in a plant properly installed.

Designing Labyrinth Stuffing Boxes for Steam Turbines

By P. Faber

When the dividing wall between two steam spaces, or steam and air spaces of different pressures, is pierced by a moving part, it is made as nearly steam-tight as possible. In steam turbines we very often find the labyrinth packing. As these packings are applied to tighten between spaces of very different pressures, varying not only from system to system, but also from unit to unit in the same system, it may perhaps be of some value for the designing engineer, to have a short, exact method of calculating this packing. The labyrinth stuffing box consists of a series of widenings and narrowings through which a certain amount of steam (the leakage of the labyrinth packing) passes. This leakage can, however, be decreased by an increase of the number of labyrinths.

The action of the steam is as follows: Let p_1 be the pressure at the beginning of the stuffing box, T_1 the absolute temperature of the steam and λ_1 its heat contents (heat necessary to transform water from the melting point to steam of T_1 temperature and p_1 pressure). We call the pressure in the chamber A, Fig. 1, p_a. The steam will expand from p_1 to p_a, and during this expansion be brought to a certain speed w* in the narrowing at point M, where the heat contents of this steam will be λ_a. According to the formula (Stodola, "Steam Turbines"),

$$\lambda_1 - \lambda = A \times \frac{w^2}{2g}, \qquad (1)$$

where A is the mechanical equivalent of heat and g the acceleration of gravity.

We call G the weight of steam flowing through the stuffing box in one second, α may be the specific weight, v the specific volume of the considered steam at point M, when the sectional area of the narrowing may be f.

The law of continuity gives the equation:

$$G = f \times w \times \alpha = f \times w \times \frac{1}{v}. \qquad (2)$$

On account of the very short space between two widenings, we can neglect all friction of steam and all transmission of heat and thus consider the expansion as adiabatic. This gives us the entropy constant:

$$S = Constant. \qquad (3)$$

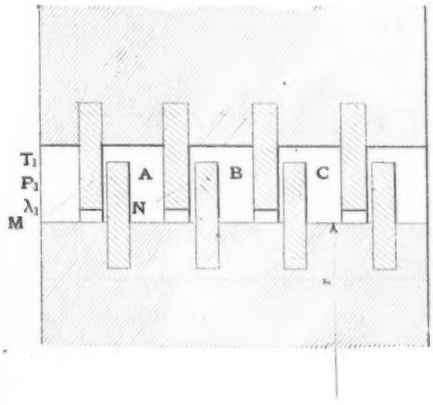


FIG. 1

The law of conservation of energy says

$$\lambda + K = Constant. \qquad (4)$$

during the whole passage of the steam, where K is the kinetic energy of the moving steam and λ the heat contents of the same steam. As we have no motion at the entrance of the stuffing box $K = 0$, and the constant in equation (4) equals λ_1:

$$\lambda + K = \lambda_1. \qquad (4a)$$

In the chamber A the pressure always remains p_a, and since the kinetic energy of the arriving steam is continually destroyed by whirlings, K is brought to 0 and equation (4a) gives

$$\lambda = \lambda_1 \qquad (5)$$

This action of the steam is the same as in a throttling valve.

To Solve the Problem Graphically

Let us proceed to solve the problem graphically, using Stodola's table of entropy:

The initial pressure p_1 and temperature T_1, which are given, locate the point A, Fig. 2, showing the state of the steam and λ_1 at the beginning. During the following expansion from p_1 to p_a equation (3) applies, which is represented in the table of entropy by a vertical line a-a. Furthermore, the expansion is determined by (1) and (2), which, combined, give the new one:

$$\lambda = \lambda_1 - \frac{A}{2 \times g} \times \frac{G^2 \times v^2}{f^2}. \qquad (6)$$

This formula gives the value of λ during the expansion for different specific volumes. We determine λ for the different values of v, given in the table of entropy, as per the dotted lines 0.15, 0.2, 0.3, 0.4, 0.5, etc., and draw through these points the curve $C\,C$, which is a curve of Fanno, of constant area, mentioned by Stodola in his book "Die Dampfturbinen," 3. Auflage 1905.

The intersection of a-a and $C\,C$ at the point B gives us the state of the steam in the narrowing at the point M, Fig. 1. In the chamber A the kinetic energy is destroyed by whirlings and the equations $p_a = Constant$ and $\lambda = \lambda_1 = Constant$ determine the state of the steam in the chamber A. It is transformed from moving steam with the speed w and heat contents λ to a stagnant steam with heat contents λ_1, having always the pressure p_a. Following the curve of constant pressure p_a, passing through the point B, Fig. 2, we reach at the point C the curve $\lambda_1 = Constant$, which gives us the conditions of the steam in the chamber A.

The next expansion to the chamber B is again shown by a vertical line b-b [formula (3)]. As the initial quantity of heat for this expansion is again λ_1, f considered the same as before and G necessarily constant, the formula (6) is not changed and gives the same curve $C\,C$. The new intersection D shows the state of steam at the point N, Fig. 1. Following a line of constant pressure, we find at the point E, Fig. 2, the conditions of the steam in the chamber B.

It may be seen from this that all the different states of the steam passing through the stuffing box may be shown by drawing the zig-zag line $S = Constant$-$p = Constant$ between the limits $\lambda_1 = Constant$ and Fanno's curve of constant area.

Every point of the curve $C\,C$ gives for a certain λ a certain v, and thus, according to equation (2), a certain speed w. If we should follow the curve $C\,C$ in our expansion, as is done, for instance, by steam expanding in a pipe of constant sectional area, we should reach the point F, Fig. 2, and here the steam would have

*Using the abbreviations introduced by Stodola.

†B. Pochobradsky, engineer in Prague, used formulas (1) and (2) in a more analytical manner, estimating v from the table of entropy, figuring λ, correcting v and λ again for each labyrinth separately.

the velocity of sound. The curve of constant area $C\,C$ turns back and an increase of the speed would involve a decrease of the entropy, which is impossible. That

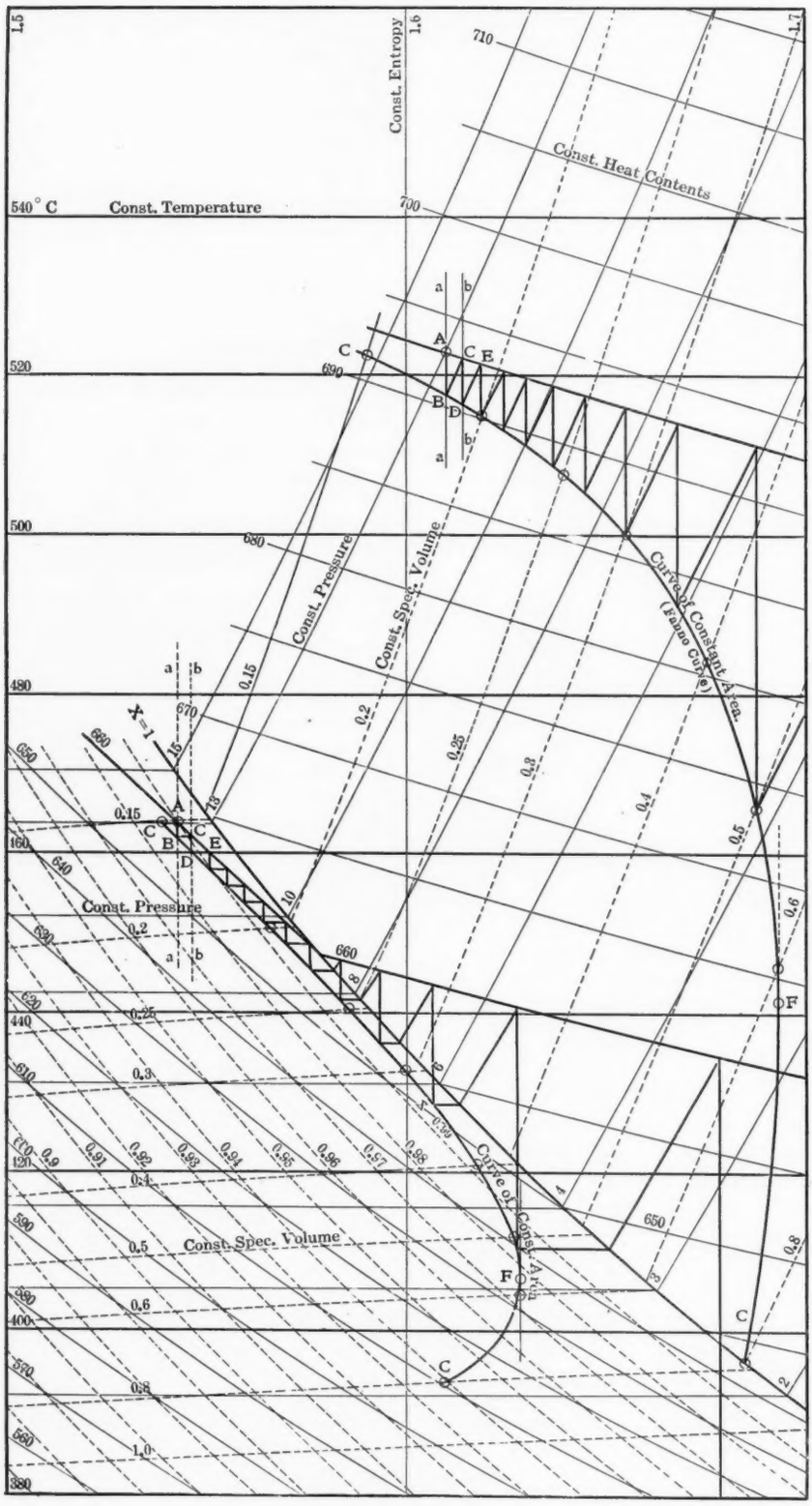


FIG. 2

means that whatever the drop of pressure from here to the pressure of the other space may be, the speed of the steam is not increased, and only the weight G passes through the stuffing box.

We can therefore terminate the labyrinth packing here, and the number of zig-zags gives the number of necessary labyrinths. The needed work to design a labyrinth packing is therefore entirely independent of the number of labyrinths.

Fig. 2 shows the calculation of two different cases for superheated and partly moist steam. The data are:

(1) $G = 0.6$ *lb. per sec.*

$f = 2 \times r \times \pi \times s = 2 \times \pi \times 10 \times 0.008 = 0.528$ *sq. in.*

$t_1 = 250°$ *C.*

$p_1 = 13$ *at.*

(2) $G = 0.6$ *lb. per sec.*

$f = 0.4396$ *sq. in.*

$X =$ *Quality of moist steam* $= 0.99$.

$p_1 = 13$ *at.*

It will be seen, also, that the method is not changed at the limit of moist and superheated steam. The curve of constant pressure has only become a broken line. It is self-evident that the zig-zag line is also terminated if the pressure of the other space is reached before the velocity of sound is realized.

Recapitulation

To find the number of labyrinths in a stuffing box of a steam turbine, proceed as follows:

(G = allowed leakage; T_1 = absolute temperature in degrees Centigrade; f = sectional area in the narrowest part of the stuffing box; p_1 initial pressure.)

Locate on the table of entropy* the point A, being the intersection of $T_1 =$ *Constant* and $p_1 =$ *Constant*. Draw $\lambda_1 =$ *Constant* through A and the curve

$$\lambda = \lambda_1 - \frac{A}{2g}\,\frac{G^2}{f^2}\,v^2 =$$

$$\lambda_1 - 59.434\,\frac{G^2}{f^2}\,v^2,$$

by determining the points of this curve on the dotted lines $v =$ *Constant*. There are introduced G in pounds per second and f in square inches. The other units are those used in the table of entropy.

Starting from the point A we draw the zig-zag line $S =$ *Constant* $p =$ *Constant* and count the number of zig-zags from the initial pressure to the pressure of the other space, or to the point corresponding to the velocity of sound, which gives us the number of labyrinths.

Sliding Scale Salary for Engineer

The unusual method of remunerating an engineer of an electrical undertaking by results has been adopted at Maidstone, in Kent, England. When the total works cost per unit, i. e., excluding capital charges, shall be 1⅛ pence, the salary of the engineer in charge is to be £300 per annum, and for each £100 saved to the Council through the reduction in the cost per unit sold a bonus of 20 per cent. per annum is to be paid. "One hardly knows," says the London correspondent of the *Western Electrician*, "whether to regard it as a sporting offer by the engineer or as an indication of the existence of a large margin for reducing the costs."

*Stodola: "Steam Turbines."

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

A Live Steam Blower

We have a return-tubular boiler with grates 5½ feet square. Our chimney was defective and had to be taken down. We were running with 28 feet of 26-inch iron stack put up through the roof, and could not get enough draft to keep up steam. I put a jet in the stack, but that was noisy and wasteful, so I fixed up the blower shown in Figs. 1 and 2, which gives a draft of ⅝ inch. A friend put one on his boiler, where he was burning two tons of soft coal. He now burns one ton of soft coal and one ton of hard-coal screenings and makes a saving of $3.50 a day.

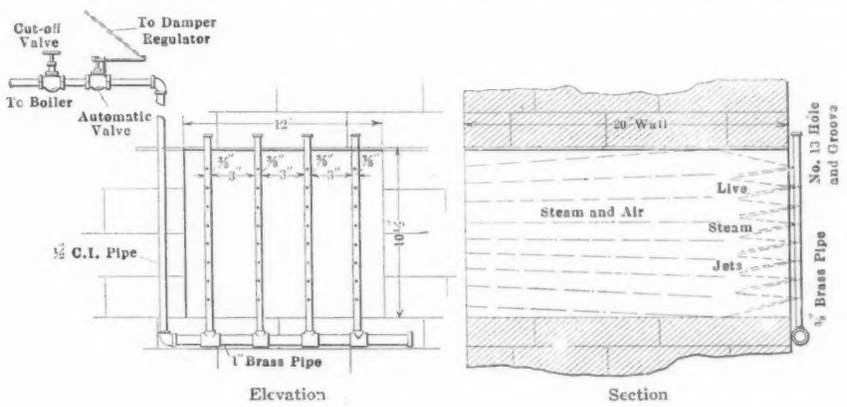


FIG. 1

We are burning screenings and soft coal, mixed half and half, under a water-tube boiler, with a draft of ½ inch. I also have a blower fitted to this boiler to use in an emergency. This blower is fastened to the side of the boiler setting and blows through a hole 12 inches wide and 10½ inches high. It is constructed of 1-inch boards, 12 inches wide, and fits in the frame of the ash-pit door; a ½x1-inch strip on the sides and bottom butts against the door frame, while a piece of board nailed between the ½-inch strips over the top covers the curved part of the door frame. The thirty small holes shown are 1½ inches apart and of No. 13 B. & S. copper-wire gage in size. This blower gives ⅝-inch water pressure under a 5½-foot square grate.

HARRY U. WENDELL.

Melrose, Mass.

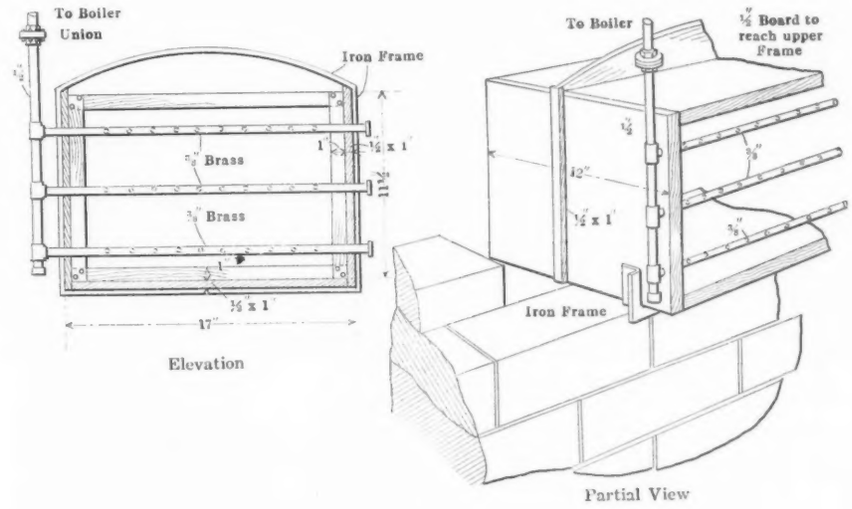


FIG. 2

How a Pounding Engine Was Cured

Some years ago I had an experience as chief engineer in a small electric-light plant which consisted of one 18x24-inch automatic Russell four-valve engine, one 15x13-inch Chuse automatic engine and two 72-inch by 18-foot return-tubular boilers, carrying 125 pounds pressure. The Chuse engine carried the day load.

The first evening I was on duty I did not know whether to stay or leave. I started up the Russell engine and such thumping, knocking and hammering I never heard. I asked the superintendent what the trouble was, and if the engine always ran that way. He informed me that it always had. When the peak load came on I had to step into the fireroom and give the fireman a hand with the two boilers.

The next day I went on watch at 9:30 a.m., instead of at noon, and told the second engineer he could go home, as I wanted to do a little work. On removing the valve-chest cover of the Russell engine, I discovered that the port was closed when the engine was on the center. After the fireman had turned the crank to the quarter, the cutoff valve began to open. This I changed to the proper position by shifting the governor wheel. After putting on the steam-chest cover I started up, but the engine speeded up and would have wrecked itself if I had allowed it full throttle. I then loosened up the springs and added weights enough to get the required speed. The engine ran so smoothly when the peak load came on that the superintendent called me up from the office, which was two blocks away, and wanted to know why I did not start up the Russell engine, to take the peak load. When informed that it was running, he made a sprint to the plant to see if I had told the truth, as that was the first time it had not made a noise which could be heard in the office. When the peak load came on, the fireman "took it easy" and said it was "like getting money from home." The amount of coal used was 60 per cent. less than before the change. The lights were steady and the place quiet and the superintendent all smiles.

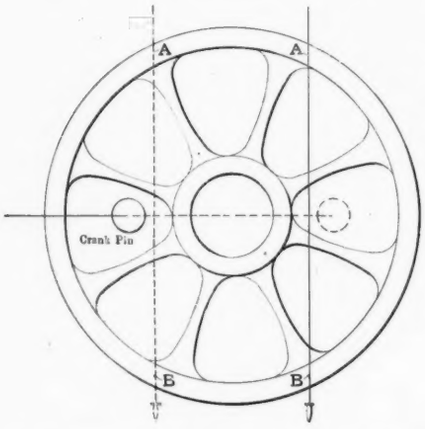
MANLEY J. MERRELL.

St. Louis, Mo.

Placing an Engine on the Center

In the July 7 issue Lucien Jones illustrates the common method of putting an engine on the exact center. I have seen engineers laboriously put an engine on one center by this method, and then as laboriously put it on the other center.

After getting an engine on one center a quick method of getting it on the other



is to drop a plumb line from any point, as at *A*, on the upper half of the flywheel, and carefully mark the position of the line on the lower half, as at *B*. When these points coincide with the plumb line on the other side of the shaft, the engine is on the other center. By making the marks permanent the engine can, at any future time, be readily placed on either center.

R. O. Richards.

Framingham, Mass.

In the July 7 issue, page 24, Lucien Jones gives a method of setting an engine on dead center. In every description of setting an engine on the center that I have seen we are told to bar the engine over in the direction in which it is to run, if the direction is mentioned at all. "Power Catechism" has the following to say:

"In all the operations of putting the engine on the center, care must be taken that the engine is always turned in the direction in which it is to be run, because in that way the lost motion, backlash or play of the reciprocating parts will make itself felt in precisely the same way as under running conditions, etc."

If the engine is turned by means of the flywheel in the direction it is to turn, the backlash will *not* make itself felt in precisely the same way as under running conditions, but the very opposite is true.

Let us take an engine at the end of the stroke with the piston at the head end, the engine running over. Under running conditions the piston is pushed, by the inertia of the flywheel, against the force of the confined steam of compression. The crank becomes the driver and the parts are all under compression, the crankshaft is forced out against the outer side of its bearing and the system is shortened as much as the lost motion will permit, as shown in Fig. 1. These conditions will prevail until the compression at the crank end reverses them, except that the piston becomes the driver. In barring the engine over the system is under compression or shortened until the center is passed. The crank is still the driver, but it now pulls instead of pushes the piston. The crankshaft is forced against the inner side of its bearing and the system is elongated as far as the lost motion will permit, while under running conditions it would be shortened. If the engineer runs with bearings as loose as good practice will permit, the loose play may amount to considerable. Furthermore, if he runs with maximum compression the piston may still be dragging the crank at the extreme end of the stroke, and if this were the case the error would be doubled.

With compression, the lines on the guide and crosshead should be brought

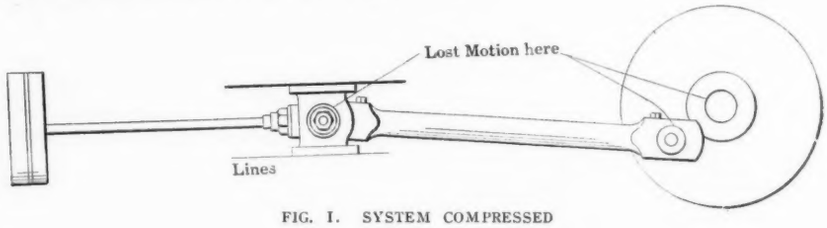


FIG. 1. SYSTEM COMPRESSED

into line with each other as the crosshead is approaching the extreme end of its stroke, whether the crank is above or below the center.

With no compression, the engine should be barred the opposite way from which it is to run. If the line on the crosshead is carried past that on the guide it is not necessary to turn the engine completely over, but it should be turned in the opposite direction far enough so that the lost motion will be all taken up before the lines again approach each other.

Most engineers are content to put the engine on the center by placing a spirit level on the brasses on the connecting-rod end, thus relying for accuracy on the work of the machinist who made the parts. It certainly is a waste of time carefully to put the engine on the dead center by trams or markers for the purpose of setting the valves and then guess at the amount of lead. The indicator must be relied upon for the final correct setting of the valves, anyway.

W. G. Talbott.

Lincoln, Neb.

Thickness of Boiler Plates

In the June 3 number, page 991, Mr. Carey took exception to parts of my letter of April 28. My understanding of the word prejudice is: An opinion formed with an incomplete knowledge of the facts in the case. To say that an engineer should be prejudiced against inferior packings, supplies, etc., is hardly good usage of the word. An engineer dislikes them because he knows they are inadequate, but if he condemns them without a fair trial or examination, he is certainly prejudiced against them. I hardly think that this can be my case in regard to 72-inch horizontal return-tubular boilers. I have been familiar with the design, construction and operation of large tubular boilers for twenty years, so that my opinions, if they are erroneous, can hardly be said to have been formed hastily or with an insufficient knowledge of the boilers.

Mr. Carey gives an instance of a battery of 84-inch return-tubular boilers, of ⅝-inch plate, with butt-strapped joints. I do not believe those boilers would be allowed to operate under pressure in the Mississippi valley, because at the girth seams the plates are more than 1 inch thick. It is customary to limit the double thickness of the sheets to 1 inch (some say less) on externally-fired boilers, as it is possible to heat one side of a thick plate faster than the water can absorb the heat from the other.

This was the reason I limited the thickness of plate to $\frac{16}{32}$ inch in describing an

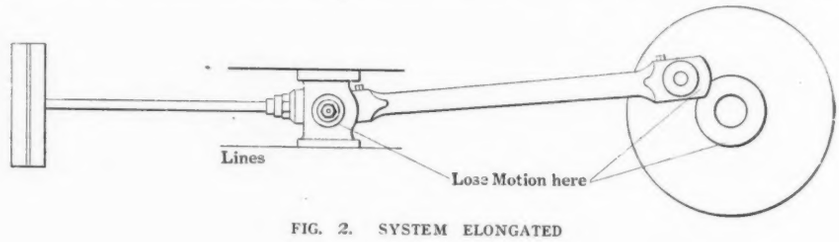


FIG. 2. SYSTEM ELONGATED

80-horse-power tubular boiler. I did not stop to figure the stress on the sheets, as I took the dimensions from an existing boiler which was built for 200 pounds working pressure and has been carrying 205 for several years. Even so, we calculate things a little differently here in the West than they do in Massachusetts. The laws of most of our western States do not specify what factor of safety to use, and I don't think we have any more boiler

explosions per 1000 inhabitants than our eastern friends. "POWER Catechism" states on page 38, Q. 213, that: "The safety factor commonly used on steam boilers is from three and one-half to five." The U. S. marine rule gives 3½, which is about as much too low as the factor of 5 is too high, which Mr. Carey says is required by some cities. Four or four and one-half is all that is necessary, for it is very true, as he says, that any boiler may be abused and short-lived, in spite of any factor that may be used. All boiler formulas are deficient in that they are based on the ultimate strength of the plate and not on the elastic limit, which is what really concerns us. The elastic limit of good boiler plate, as made nowadays, is in excess of 32,000 pounds to the square inch and the safe allowable fiber stress should not be taken for more than one-half of this, or 16,000 pounds. Using this for a basis for calculation we get, in the case first mentioned,

$$\frac{16{,}000 \times 2 \times \frac{15}{32} \times 0.875}{60} = 218.75$$

pounds.

The Carnegie Steel Company recommends a maximum fiber stress of 15,000 pounds per square inch for steel used in all construction except bridges subject to rolling loads. This gives us

$$\frac{15{,}000 \times 2 \times \frac{15}{32} \times 0.875}{60} = 205.08$$

pounds.

This corresponds to Mr. Carey's formula with a safety factor of four, and would be safe for ordinary use, but, as he points out, would not pass Massachusetts' requirements. I have used an efficiency of 0.875 for the joint which is the one I am most familiar with. The rivet spacing can be rearranged to give a little higher efficiency, some writer a few years ago claiming 94 per cent. to be obtainable. I have forgotten the arrangement now, as it did not impress me favorably at the time. As a matter of fact, the butt-strapped joint, when tested to destruction, has frequently failed in the solid plate, owing to the friction of the cover plates.

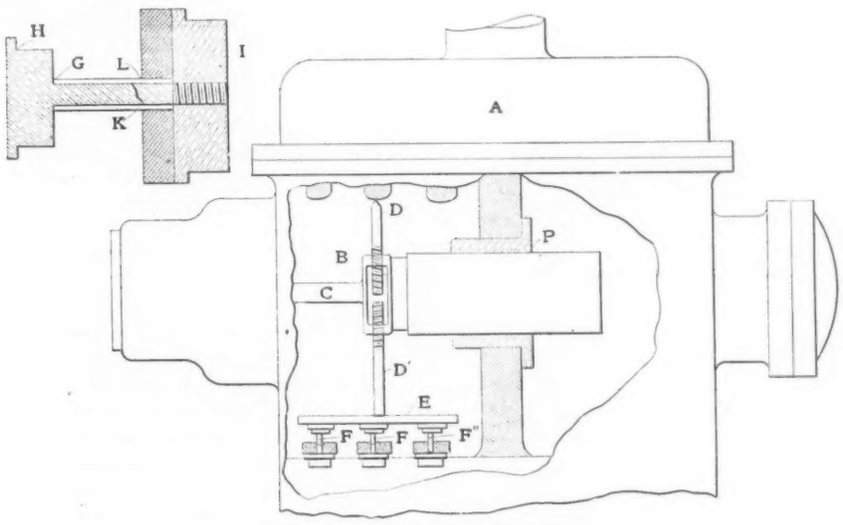
LEROY BAKER.

St. Louis, Mo.

An Emergency Pump Repair

I was called upon to make an emergency repair to a high-duty pumping engine. Three valve guards became broken in the inboard suction chamber of a plunger-and-liner fitted water cylinder, and the pump had to be kept constantly in commission, in connection with another pump of the same size, to maintain a required pressure.

Just how to get the pump going was at first a problem, for I knew that it would take at least a day to remove the plunger, liner and valve seats. The plunger was 13 inches in diameter, so nobody could get into the inboard chamber without the removal of the liner. It finally dawned on me that I could easily repair it, as shown in the accompanying sketch.



AN EMERGENCY PUMP REPAIR

At *A* is the water cylinder, at *F*, *F'* and *F"* are the three broken valve guards. We tried to screw the broken guards out of the seats, but the guards were of soft brass and would not turn out. I procured a plate 1 inch thick, 18 inches long and 4 inches wide, as shown at *E*, and placed it over the three broken guards. I next obtained a 1½-inch turnbuckle, as shown at *B*. I filed a point on one end (*D*) of one screw rod and left the end of the other screw (*D'*) flat.

There being but two handholes, one on either side of the suction chamber, it was quite a job to get the turnbuckle set tight. By applying a pipe wrench to the lower stub end at *D* and allowing its handle to strike against the water-cylinder wall, a man holding a pipe wrench on the upper stub at *D*, I was able to turn the buckle from the opposite handhole, with the aid of a flat chisel 24 inches long.

At *K* is shown the break in the guard, and *G* shows how I fitted a small piece of brass tubing over each shank to keep them in place. At *I* is shown how the rubber valves had to be reamed out ⅛ inch to allow them to lift freely from their seats; *H* shows the guard. Suitable springs of 3/16-inch brass wire, five coils high, are used over the valves, but have been omitted to show more clearly the repair.

C. W. DUNLAP.

Depew, N. Y.

Air Leakage in Condensers

In the July 14 issue, page 74, is a paper on a subject similar to the above, and the following is the method by which I persuaded most of the air to stay outside, where it came from.

In all condenser casings in my younger days, there were from 6 to 12 "chaplets" between the external mold and the internal core; to insure uniformity of thickness of the metal, a necessary matter, because all the side openings were on one side only; and as these chaplets were of wrought iron, they did not weld and when the casting cooled there were air leaks.

As riveting never completely closed these leaky spots, I contrived that the pin of the chaplets should project externally, and a hole was drilled, which removed the chaplet; then the hole was tapped and a bronze plug screwed in solidly; that stopped the leakage of air, but as we took our feed water from the hot well, where the temperature averaged only 120 degrees, we still had some air in the condenser, but there was a marked difference between the air blast in the space above the air-pump bucket and that which we heard after the chaplet leaks were stopped.

Air entering with the water that is to condense the steam cannot be rated as leakage. Water always contains air, and the colder the water the more air is in it, and there is always some air in water until it is boiled, when it is useless in a condenser. And even if you cool it enough some air will get back into it.

The surface condenser is a great relief in this case, for the air-choked water is on one side of the tubes and the steam on the other side, where if the chaplet holes are stopped, even Mr. McBride gives us a hope of too small an amount of air (three-tenths of 1 per cent.) to give us any trouble, unless you use a very powerful microscope along with your calorimeter.

PETER VAN BROCK.

Jefferson, Iowa.

Cause of a Pound in a Gasolene Engine

On page 929 of the June 9 number an inquirer asks what makes a 65-horse-power gasolene engine pound. The answer given is O. K. as far as it goes, but I think the principal reason for the pound is that there is too much spark advance for the load carried.

The writer is operating a 60-horse-power gasolene engine belted to a pump and an electric generator, each consuming approximately 30 horse-power. When the pump or generator is running alone, the spark advance is such that the engine runs quietly with its ordinary charge of gasolene, but when both pump and generator are running, giving the engine about full load, the engine will pound, due to the cylinder getting so much hotter and the mixture burning more quickly, unless a small quantity of water is admitted to the cylinder. There is a special water valve for this purpose.

Retarding the spark will stop the pound, but the engine will not work at best economy on light loads, if this is done; consequently, as full load is on only a few hours each day, it is considered best to give it all the spark advance it will stand on half load, and then feed in a little water on the heavy load, which entirely kills the pound.

J. E. Bates.

Spirit Lake, Idaho.

What Caused the Pound

In answer to Mr. McCann's inquiry, I would say that at the plant where I am employed we have a 14x36-inch simple Corliss engine running at 90 revolutions per minute. The engine was taken from another plant three years ago, and ever since has developed a very hard and disagreeable pound just as the crosshead leaves the head-end center.

Numerous attempts had been made to stop the pound, but without success. Upon taking the follower plate off I found that a sectional ring was originally held out against the cylinder by springs, which had worn and become so weak that they did not hold the ring out, with the result that when steam was admitted it got between the ends of the ring, forcing it out against the cylinder and causing the pound. As there were no new springs at hand, the ring was removed temporarily, and when the engine started the pound had entirely disappeared.

Ralph F. Blanchard.

Fitchburg, Mass.

The cause of Mr. McCann's pound is that the compression is entirely insufficient for an engine making 80 revolutions per minute. If the engine was in my care the first thing I would do would be to move the eccentric ahead at least ¾ of an inch in order to quicken the closing and opening of both exhaust valves, and then set the steam valves back to their proper place by the radial rods.

If the engine still pounds the main bearing should be investigated to see that the quarter boxes are a good fit on the shaft and that the inside cap bears evenly on the quarter boxes; also see that there is plenty of room between the inside cap and the shaft, and that there is no possible chance for the cap to touch the shaft. Then screw down hard on the cap bolts so that the quarter boxes may be held firmly in place.

When desiring to take up lost motion it is well to slacken a little with one cap bolt, and if the main bearing is found O. K., the next places to look would be at the crank-pin and crosshead-pin brasses and examine them for side play.

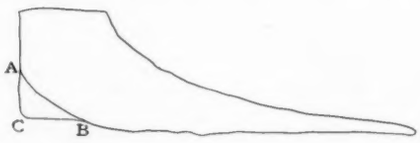
S. A. Smith.

Henderson, Ky.

A Compression Argument

They sat in the smoking car, one reading the morning paper, the other perusing the July 14 issue of Power and The Engineer.

"Huh!" said the latter, "what do you



think of these editors opening up that compression and lead discussion in the middle of July, and one of the hottest Julys at that? You don't believe in compression, do you 'Bill'?"

"I do," answered "Bill."

No. 1, who answered to the name of "Tim," looked at "Bill" and said:

"Look here, I thought you had progressed far enough along the lines of common sense to wash that engine-builders' dust out of your eyes. Have you ever heard how compression originated? An engine builder built an engine that pounded. He couldn't key it up tight enough without getting the boxes hot. In desperation he tried different settings of the valve, and finally hit upon compression. To justify this, he began to look for some arguments in its favor, and this dust has been in the engineers' eyes ever since. Now look at this card I have drawn. Here at *A B* is as nice a compression as anyone would care to see. Suppose this card figured out 100 horsepower. Now, instead of that curve, suppose I have a square corner as at *C*. You will admit now that the area of that card is greater, and that the horsepower figured from it will be more. You admit this, don't you 'Bill'?"

"I do," said "Bill," "but—"

"Now you let me finish first, and then I'll listen to you," interrupted "Tim." "If the card with the square corner figures out more than 100 horsepower and our load is just 100 horsepower, it stands to reason that the governor must cut off the steam earlier, in order to give the same card area as before, and an earlier cutoff is a saving of steam, is it not 'Bill'?"

"You are like the rest of them, 'Tim'," answered "Bill". "You know, well enough, that you cannot accurately figure the steam consumption from an indicator card. The indicator will not tell you how much cylinder condensation has taken place, and you must admit that there is more condensation in a cylinder with no compression than in one using compression."

"I admit that," said "Tim."

"Now, can't you see that the greater condensation offsets the gain in the earlier cutoff?"

"No. That is a thing my common sense will not admit of. You have admitted that I secure an earlier cutoff with no compression. Now you must also admit that the steam enters the cylinder only while the valve is open and as the valve is open a shorter time with no compression it must be using less steam condensation or no condensation."

"Well, but how about cushioning the reciprocating parts of the engine?" asked "Bill."

"They don't need it," answered "Tim."

Just then the train came to a sudden stop and both "Bill" and "Tim" were pitched out of their seats, landing with a sudden jolt against the end of the car.

"How about a little compression now, 'Tim'?" queried "Bill." "Wouldn't a little cushioning between your head and the end of the car have helped in stopping the moving parts?"

But "Tim" answered never a word.

R. O. Richards.

Framingham, Mass.

Belt Lacing

In the July 21 number, J. E. Strother advises the use of leather lacing. I have used both leather and wire lacing on high-speed belts and find the wire lacing the best in every way. It will last longer and there is not as much danger of a belt breaking with wire as with leather lacing.

I would like to have him explain why a wire lacing cannot be pulled up as even and as smooth as a leather lacing. If the ends of the belt are square and placed evenly against the rolls of the belt-lacing machine and an eye kept on the work, it cannot help being smooth and even, if the machine is any good.

D. C. Steinman.

Maynard, Ohio.

Homemade Packing

In a starch plant where the writer was employed the firm considered the boiler and engine room as a necessary evil, and never thought of buying manhole gaskets or packing. Muslin was used to strain the starch, and when the cloths became too old and sour they were turned over to us and used for manhole and handhole gaskets. We would tear them in strips and make a braid about 1½ inches wide. The braids were then saturated in cylinder oil, and as steam was raised, we would pull up on the gaskets. It was very seldom that this packing gave out.

For packing pumps and engines we used old hose, which was largely employed in transferring the starch. We would split the hose, then lay it flat on a board and cut out gaskets the size wanted, with different sizes of pipe, ground on the outside edge on one end and using a mallet on the other end. These gaskets were soaked in oil and did very well.

EDMOND HERZOG.

Chicago, Ill.

Unequal Points of Cutoff

A recent issue of POWER AND THE ENGINEER contains a very interesting article by W. H. Wakeman, entitled "Unequal Points of Cutoff," in which are mentioned two different methods whereby a shaft governor may control the speed of a steam engine: First, by changing the angle of advance by rotating the eccentric upon the shaft; second, by changing the radius of eccentricity by swinging the eccentric across the shaft. This is very good as far as it goes, but the article in question might have been a little more comprehensive and included mention of a third method of accomplishing regulation, by changing both the angle of advance and radius of eccentricity.

As a matter of fact, neither type of governor described in Mr. Wakeman's article could be used on an engine in which all of the events in the stroke of the piston are under the control of a single valve, for the very obvious reason that a change in the point of admission would accompany every change in the point of cutoff.

In the case of an independent cutoff valve, however, such as is used in the Buckeye engine, the plan of changing the angular advance to obtain an earlier or later cutoff answers admirably, for in this instance admission of steam to the cylinder is under the control of a main valve actuated by a fixed eccentric; the office of the cutoff valve being simply to cut off the flow of steam through the port opening given by the main valve, and nothing else.

But for that numerous type of automatic cutoff high-speed engine in which the functions of admission and cutoff are performed by a single valve, it is necessary to devise a method of control whereby a constant lead can be maintained regardless of the point of cutoff. This can only be accomplished by a combination of the two eccentric movements described in Mr. Wakeman's article. The accompanying valve diagrams illustrate the point.

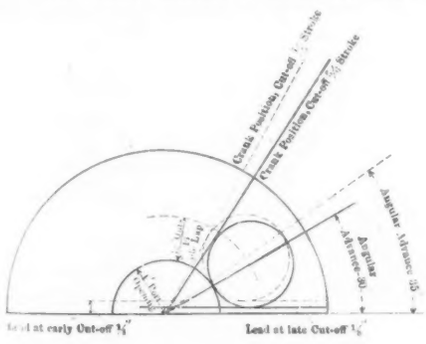

Crank Position, Cut-off ⅕ Stroke
Crank Position, Cut-off ⅘ Stroke
Angular Advance 30°
Lead at early Cut-off ⅛"
Lead at late Cut-off ⅛"

FIG. 1

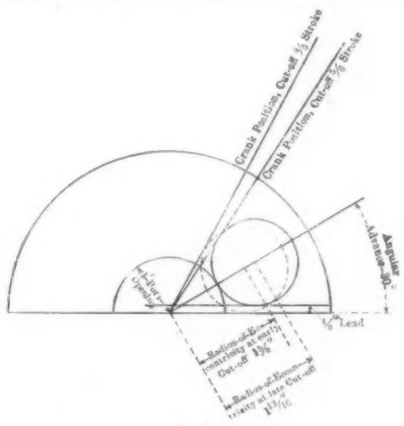


FIG. 2

The diagram in Fig. 1 shows a valve cutting off at 5/6 of the stroke with the eccentric advanced through an angle of 30 degrees, and also the effect of increasing the angle of advance to 35 degrees. It is observed that while the valve gives ⅛ of an inch lead during the period of maximum cutoff, advancing the eccentric to effect a cutoff at 4/5 of the stroke also causes the lead to increase to ¼ of an inch. Consequently, to prevent excessive lead with this style of governing a single-valve engine, the range of cutoff would necessarily have to be fixed within very narrow limits.

The diagram in Fig. 2 shows a valve giving the same lead and maximum cutoff with the same angular advance and radius of eccentricity as in Fig. 1, and also the effect of diminishing the radius

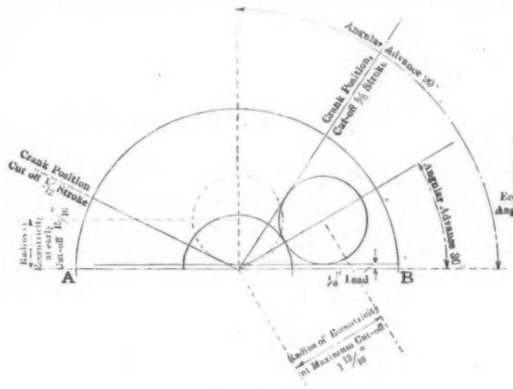


FIG. 3

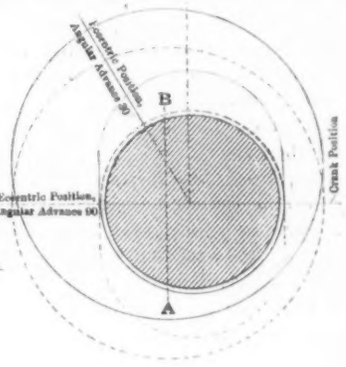


FIG. 4

of eccentricity. It is seen that shortening the eccentricity an amount sufficient to bring about cutoff at 4/5 of the stroke annihilates the lead altogether, and it is also plainly evident that any farther decrease in the eccentricity would cause the valve to open for admission after the piston had started on its stroke. Therefore, to prevent late admission with this method of regulation, it would be necessary to fix the range of cutoff within even as narrow limits as in the case of the rotating eccentric.

The diagram in Fig. 3 shows the same lead and maximum cutoff with the same angular advance and radius of eccentricity as in the two previous illustrations, and also the effect of diminishing the eccentricity and at the same time increasing the angle of advance to accomplish an earlier cutoff. In this instance, it is observed that while the point of cutoff may range from 1/12 to 5/6 of the stroke, the lead remains constant at ⅛ of an inch; the port opening varying meanwhile from the full port of 1 inch at the point of maximum cutoff, to the lead of ⅛ of an inch at the point of minimum cutoff. It is also to be observed that in the eccentric movement required to bring about this result, the center of the eccentric follows a line parallel to *A B*, Fig. 4, the line from which the angle of advance is laid off, and which is, as a matter of course, at right angles to the crank. Therefore, in order that a single-valve engine may have a wide range of cutoff with constant lead, the governor must be so devised as to shift the eccentric across the shaft in a line perpendicular to the crank as the line *A B*, shown in Fig. 4.

A. J. DIXON.

Chicago, Ill.

Novel Method for Renewing Metallic Packing

While renewing metallic packing on a piston-rod in a vertical Wolfe type engine recently, we had difficulty in holding the packing up while entering the gland, owing to cramped quarters between the stuffing-box and a partition in the frame used to catch water from the cylinders and valve chambers.

The packing was made for a 3¼-inch rod and weighed 30 or 40 pounds. After trying to block it up into position for some time, we hit upon a scheme which may be useful to others.

We set the low-pressure valve so as to leave the exhaust ports open on each side of the piston. We then shoved the packing into the stuffing-box and turned on the dry vacuum which held the packing in position. It was then easy to put the gland in place.

It has since occurred to me that if the engine was a non-condensing unit, the job could be done easily by placing a clamp below the gland when the packing and gland are on the rod; then, by turning the engine over by hand and watching the gland to see that the studs entered properly, the packing could readily be brought to its place.

W. C. Dowd.

Camden, N. J.

Points on Engine Erection

In the July 21 number there is an article on "A Few Points on Engine Erection," by Thomas W. Hartley, and I would like to ask the author for a few more points, as there seem to be some things left out that would be helpful to the inexperienced engineer.

First, he says there is a foundation to prepare, but instructions as to the method are rather meager. His method of determining the depth of foundations is one that will help the inexperienced engineer, especially if erecting a second-hand engine with no foundation-bolt plans accompanying it. All you need do is take 3 feet 6 inches as the proper depth for a 150-horsepower engine and increase the depth in proportion to the size of the engine. At this rate a 1000-horsepower engine would require a depth of 23 feet 1 inch, which I should think would be O. K.

For an engine I had occasion to erect the builders advised 6 inches of concrete in the bottom of the excavation. I don't see why they should do so when 6 inches of sand is much cheaper and, I believe, would allow the engine to settle into line should the inexperienced engineer fail to get the alinement perfect.

The rest of the article is very clear and instructive until we come to the matter of regulation, where he says: "If the erector has a tachometer this will be easy." Now I have an engine that has a tendency to jump at certain loads and at other times race or hunt, and at all times there is too much variation from no load to full load. I do not possess a tachometer, consequently it is not easy for me, and as the generator is compound wound I get but little information from the voltmeter and ammeter. Now, if the author will kindly explain how I can regulate the engine with a tachometer I believe my employers will purchase one.

Ralph Braddon.

Cleveland, O.

Ejectors for Artesian Wells

Replying to Felix Hagan's query of June 16, page 953, we tried the common air lift, Fig. 1, on our artesian wells to our sorrow. We are now using, and have

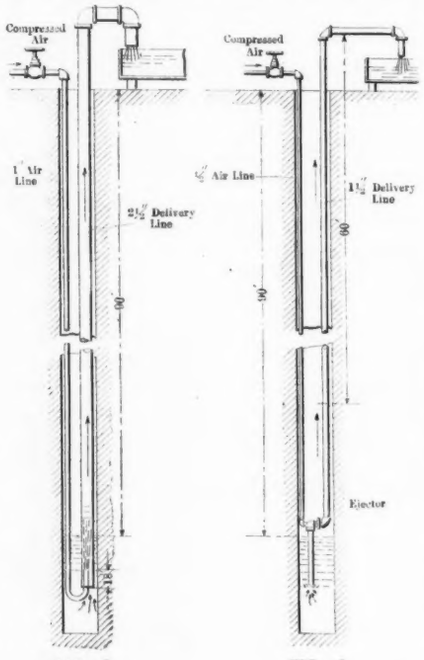


FIG. 1 FIG. 2

for nearly three years, ejectors, with perfect satisfaction and with much less air than with the air lift. Fig. 2 shows the method employed in using them.

Our compressor is rated at 68 cubic feet of air per minute, and is running about one-half time without any load while forcing 35 gallons of water per minute at a 60-foot lift and 65-pound air pressure. The wells are supplied by a ½-inch air line and have a 1½-inch delivery on a 20-gallon well. The air valve is just cracked, which forms an air bubble and displaces the water. Of course, this does not give a steady flow, but does the work with less air. The common air lift we had in use had a 2½-inch delivery with a 1-inch air line running up the end of a 2½-inch pipe about 18 inches, and would not work under 35 feet deep.

W. H. Simmons.

Owings Mills, Md.

Thinks Single Flywheel High Speed Engines Would Give Trouble

On page 957 of Power, June 16, R. Manly Orr speaks of removing the left-hand fly-wheel of a high-speed engine, and driving a dynamo from the right-hand fly-wheel.

It seems to me as if the arrangement adopted must produce an excessive strain on the right-hand bearing. I would like to ask if Mr. Orr has ever had any trouble with it?

If there was an outer bearing erected between the driving pulley and the wall, thereby giving the crank-shaft a three-bearing support, there would be less liability of future trouble with the right-hand bearing and also with the crank-shaft being eventually pulled out of line.

I would like to know if any other engineer has ever seen an engine erected in the way described by Mr. Orr, and how long it ran without giving trouble.

Henry B. Hicks.

Oriskany Falls, N. Y.

Cause of a Hot Gasolene Engine

Not long ago a friend, who owns a big touring car, complained that he could not keep his engine cool for any length of time. He said that it would start off all right and the water seemed to circulate properly; at least the pump would go; but after he had run a mile or so the cylinders would get so hot that he was afraid to run any longer, and he had to stop and let them cool off.

Inquiry developed the fact that the machine had been recently overhauled, but my friend insisted that only the dirt had been removed and no changes whatever had been made in the mechanism, and it was with reluctance that he permitted me to look over the machine, as he did not know that I had spent several years in an automobile factory, and I took no trouble to inform him.

The first glance showed that a new section of rubber hose had been put in to connect the pump with the water tank. It was the suction side of the pump, and I instantly took hold of the hose and squeezed it, and it flattened out between my fingers like an old rag. I knew then what the trouble was, so I told him to put in a section of regular suction hose in place of the common garden variety he had used and his trouble would be over.

He seemed doubtful but did so, with surprising results—to him, at least.

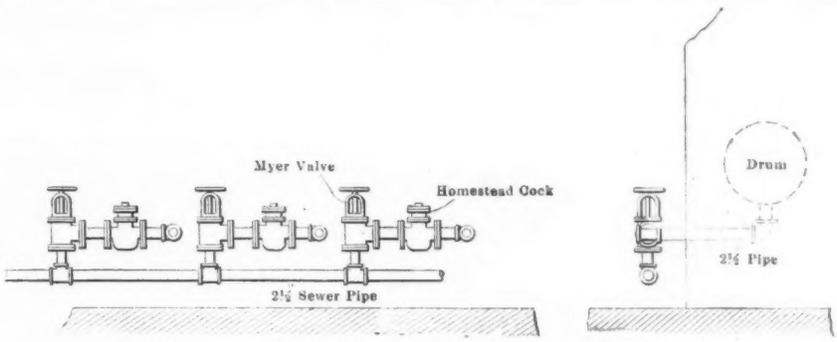
Afterward he told me that he had never supposed that the small amount of suction generated by an automobile circulating pump would cause a "piece of garden hose full of water to collapse and stop the flow"—but it did, and will every time.

Ethan Viall.

Decatur, Ill.

Blow-off Arrangement for Stirling Boilers

Having noticed several designs of blow-off pipes in POWER AND THE ENGINEER lately, I am submitting one I am using on Stirling boilers and find them very successful for handling dirty water.



ARRANGEMENT OF BLOW-OFF PIPE

The sketch shows how the pipes are fitted up. The order of using them is this: The day men blow one end and the middle valve, the night man blowing the other end and middle valve, thus keeping the drum quite clean. I tried several combinations of valves and cocks before I could get one tight; this one holds very well.

A. G. MCFARLAND.

Ilion, N. Y.

Injudicious Advertising

That every manufacturer should advertise all the good qualities of his products is good business, but no one has a right to recommend an article for a purpose that may endanger life and property. In the July 28 number of POWER AND THE ENGINEER is an advertisement by the "Smooth-On Manufacturing Company, in which the following appears:

"Not only are cracks in steam and water piping easily repaired, but boiler cracks are just as easily taken care of, and cracks that are right in the fire box exposed to the hottest flames." That "Smooth-On" cement has excellent qualities, and that it would stop a leaky crack in a boiler, I do not dispute; but for any engineer to repair a crack "right in the fire box," or any other part of a steam boiler carrying pressure, with any kind of cement or filling would be criminally reckless, and for any person to recommend that boilers be so repaired is little, if any, less reprehensible than actually doing it.

C. J. LARSON.

Dubuque, Iowa.

In regard to Mr. Larson's communication about the use of Smooth-On iron cement in the fire box of a steam boiler, we beg to state that it was not our intention to convey the idea that Smooth-On iron cement was to be used alone for stopping leaks in a power boiler, whether in direct communication with the flames in the fire box or not. We meant to convey the idea that Smooth-On could be used and is used for stopping leaks in cracks, etc., in the fire box of a boiler, but in each case we certainly expect the ordinary boiler patch to cover the Smooth-On applied in the crack, and no engineer would attempt to repair a crack in a boiler in any other way.

We do know of a number of cases where a small boiler carrying from 5 to 10 pounds pressure has been cracked in the fire box and the crack repaired with Smooth-On cement alone. We know of two boilers in this city that have been running for more than four years since such repair was made, but we do not advise it, and if it is done the engineers do it on their own responsibility. Of course, in cases where the surrounding metal is strong enough to withstand the strain the repair will be a lasting one. We know of one case where in place of using the patch the engineers forced Smooth-On into the crack, then applied bands across each end of the crack to prevent it from spreading. This was also a boiler carrying but 10 pounds pressure for house-heating purposes, but as we stated above, on all power boilers we certainly advise using patches to cover the Smooth-On. The thinner the patch the better.

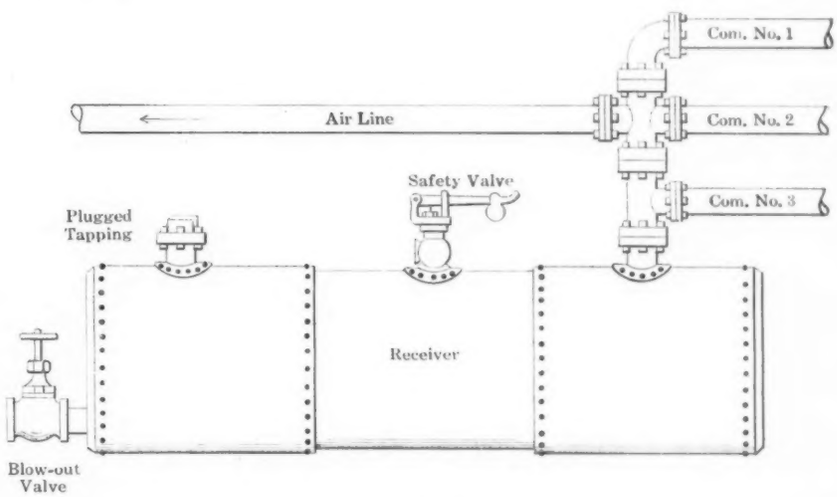
The reason we put the advertisement referred to in the paper was that we had been asked by many engineers who had used Smooth-On for repairing cracks in boilers that were not exposed to the direct flames, whether the Smooth-On could be used for boiler patching when it was exposed to the direct flames. Their reason for asking this question was that they thought Smooth-On would not expand or contract with the metal, and did not have nearly the same conductivity, and that the patch would be burned off, and so not be a lasting one. We cited instances of patches that have been made in the fire boxes of boilers exposed to direct heat for more than two years without burning off. The above inquiry led to our putting the advertisement in the paper as we did, but we do not intend to convey the idea that the Smooth-On should be used alone, as we had not the remotest idea that any engineer would think of using Smooth-On alone, without a reinforcing patch, except in cases where he had confidence that the surrounding metal was of sufficient strength to withstand the strain.

SMOOTH-ON MANUFACTURING CO.,
VREELAND TOMPKINS, Treas.

Jersey City, N. J.

Why the Receiver is Noisy

If E. Norton, who asks for the above information in the June 30 number, will connect his piping as shown in the illustration, or in any similarly convenient manner, his receiver troubles will cease. It is not only useless but annoying to pass the air through the receiving tank. The only purpose of the receiver is to cushion the discharge of air from the compressors and thus give a steady and uniform pressure and delivery at the point of application, whether operating tools, machines or lifting water from a well. This will be



PIPING CONNECTIONS OF RECEIVER AS RECOMMENDED BY J. L. BRADSHAW

accomplished just as well by piping up, as shown, as to pass the air through the receiver.

J. L. BRADSHAW.

Memphis, Tenn.

How an Old Timer was Improved

Following are a few changes which proved to be beneficial to one of the original Corliss and Nightingale engines, bearing the patent date of 1851. The regulation of this governor had always been bad when the steam pressure was above 60 pounds, necessitating running the engine throttled. The governor was so unsteady when the load was light that engineers have been known to throw off the governor belt and run by the throttle; and, from reports, the engine has run away many times. This was due mostly to the wooden knock-off sticks *A*, Fig. 1, wearing short.

On the governor stem *B*, Fig. 2, are the collars, which have been changed up and down, and there are no less than a dozen set-screw prints where engineers have tried to stop the "hunting." The original shape of the wedge is shown in Fig. 3. I took out the piece marked *X*, which lessened the travel of the governors, giving better regulation with less variation; but still there was a field for improvement, and so I introduced a 1/16-inch wire spring, as shown at *C*, Fig. 1. The spring is set so that when the engine is operating at its ordinary point of cutoff

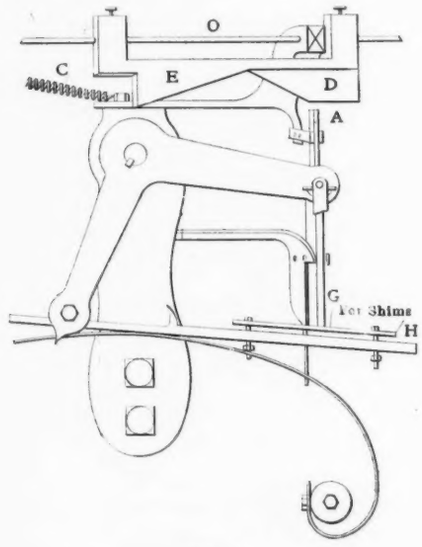


FIG. 1

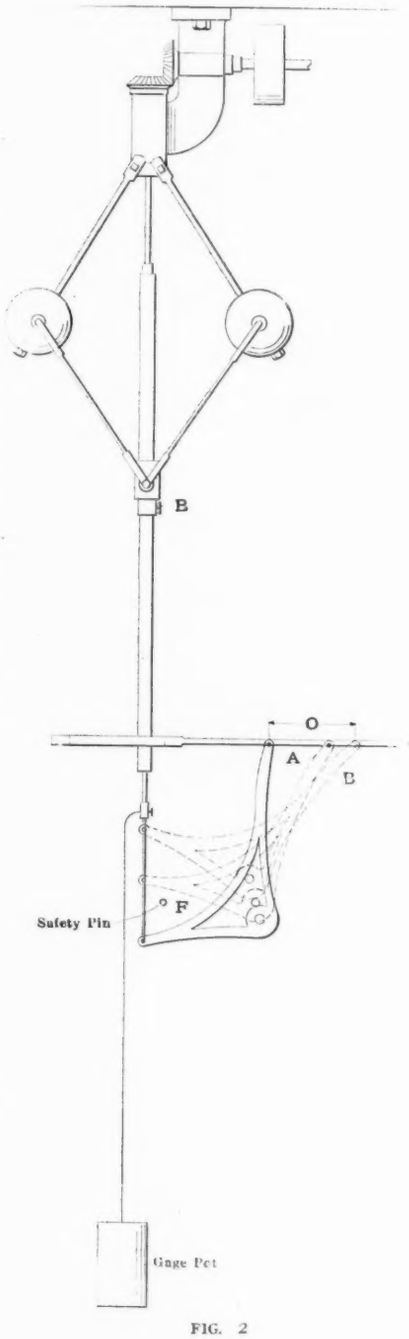


FIG. 2

the spring is given a slight tension, so that at any hunting tendency of the governor the spring tension is lessened on the upward movement, while the downward movement is resisted by the tightening of the spring. The effect is to induce the governor to keep nearly in one position. This engine having no safety attachment, a piece *D*, Fig. 1, was put on the opposite side of the cutoff wedge *E*. It is shown in the position it assumes when the governor belt breaks, or the safety pin is left out when shutting down, as it prevents the valve from hooking on.

Fig. 4 shows the position when the governor is on the pin and Fig. 5 with the ordinary cutting-off position. In Fig. 4 is shown the wooden stick which slides on the steam-valve rod and trip the valve according to the position of the wedge *E*, Fig. 1, which is moved by the governor and regulates the time the valve is kept open. This stick must be renewed with a longer one once a year, otherwise when the governor is at its highest position it will fail to reach the wedge *E*, Fig. 1, and the valve will not be tripped, causing racing. By putting on a sliding plate with two bolts as shown at *G*, Fig. 1, which can be raised or lowered, and a tin shim put between it and the rod, as at *H*, Fig. 1, the wear of the stick *A* can be taken up, which is much easier than renewing the stick.

A. C. WALDRON.

Lynn, Mass.

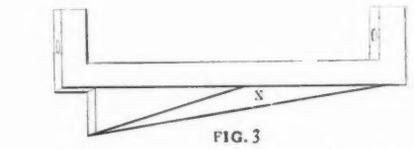


FIG. 3

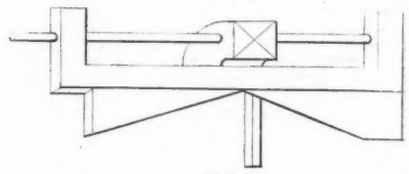


FIG. 4

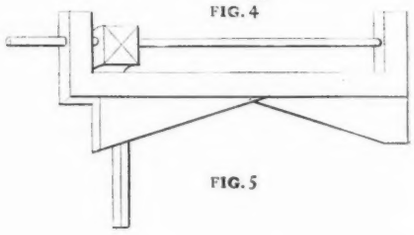


FIG. 5

A Valve Disk Caused Trouble

Some time ago the fireman called me into the boiler room, saying that considerable water had left one boiler and gone into another. The boilers in question were connected at the bottom with a mud drum and a the top by a steam main, there being a 6-inch angle valve on each dome leading into the main. The engine was immediately stopped, whereupon the water came back to its true level. I was a little puzzled as to what the cause might be, but started the engine again and before it came to full speed the water began to shift, as before.

The two troublesome boilers were cut out and cooled off and upon examining the angle valves I found that one of the disks had been pulled from the stem and was lying on its seat. The disk was fastened to the stem again and we had no more trouble.

We had trouble with these boilers several years ago, when they were connected to a 10-inch main by 6-inch outlets from each boiler, the water shifting from one boiler to the other, according to which one was over the hottest fire, although both were in one furnace. We then had a 3-inch flange put on the sides of each dome and connected the boilers by a 3-inch pipe. We had had no more shifting of water until we had the valve trouble mentioned.

R. S. LIVINGSTON.

Deweyville, Texas.

Detecting Leaks with the Indicator

In a recent number the question was raised as to whether the steam-engine indicator can be depended upon to detect leaks in valves and pistons of steam engines. In my opinion it depends in a large measure on the experience and capacity of the investigator. If he is a recent graduate of some technical school, as a matter of course he knows all about it; but if he is one of the "old liners," with several decades of practice and experience behind him, he is very skeptical and will not put himself on record in the affirmative.

I am led to this conclusion by the following facts: It was my good fortune soon after completing my apprenticeship to be detailed to assist the late Charles E. Emery in conducting some experiments at the Novelty Iron Works, in New York City. The experiments and tests were made for the Government in the early sixties (I think it was in 1864), and it was due to Mr. Emery's good will toward a "cub," who wanted to exercise his privilege as an American citizen and ask questions, that I first learned something of the science of steam.

In 1874, at the solicitation of the publishers of a technical journal, the writer prepared what he believes to be the first article published in this class of journal explaining and popularizing the use of the steam-engine indicator. From this date up to the present I have quite frequently used the indicator to determine facts and as an aid in gathering data on which millions of dollars have been invested; in this case, in particular, in which at the present time more than one hundred million dollars is being invested. Yet, notwithstanding more than over forty years' experience with this instrument, I am free to admit that I have not as yet learned how to detect a leak unless I have data other than those given by the indicator, and I am reading the views of others in the hope that I may learn something that I do not now know, for it is an old saw "that a man is never too old to learn."

While on this subject I wish to add that I think the indicator is a much abused and overworked instrument. Most any "chump" can hook up an indicator and take a card after he has once seen it done, and these are often rushed to the technical press with the request that engineers, or the editor, will discuss them; when, as a matter of fact, I do not believe the man has yet been born who can properly analyze a card, unless he knows every detail and has taken it himself, as there are a great number of factors that affect a card, to enumerate all of which would fill a column or more of this journal, and to send in cards without full data appears to me to be less than useless.

Do not understand me as wishing to discourage all intelligent criticism or discussion, as such are often highly interesting and bring out bright points, but what I do ask is that your readers who send in diagrams for discussion include full data so that others who are kind enough to discuss them can do so intelligently, and let the freak or catch diagram be consigned to—well, let us say the scrap basket, and the fakers be squelched.

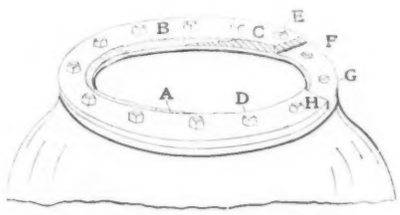
The indicator is of great value in the hands of a man who thoroughly understands it and uses it to determine where he shall use the hammer, and cold chisel, perhaps, to improve the distribution of steam.

W. H. Odell.

Yonkers, N. Y.

What Takes Place When a Boiler Explodes

The other day I had a practical demonstration of what really takes place when a boiler explodes. The case in question may not properly be called an explosion, but it was as near to it as I ever care to get. It happened on a locomotive pulling a freight train. The engine had passed about 200 feet from where I stood when the entire top of the steam dome went up in the air, carrying with it the throttle valve, safety valve, whistle and a part of the sheet-iron covering. The detonation was similar to that of a heavy shot in a stone quarry, and was followed by the roar of the escaping steam. It seems to me that it was a full minute before there was any decrease in the noise made by the escaping steam. However, in less than two minutes everything was dead. The break left a circular opening, as shown in the cut, 14 or 16 inches in diameter, and here is a little problem for those who like to dabble in figures. How much steam escaped through this opening in the first minute, and how much water was likely to have been left in the boiler after everything was quiet?



FRACTURED STEAM DOME

The pressure carried at the time of the accident was 150 pounds gage and the water was at the proper level. Rust on the surfaces showed that there was an old break extending entirely through the casting from *A* to *B* (see illustration), and partly through from *A* to *D* and *B* to *C*, so that practically there were only the bolts *E*, *F*, *G* and *H* and the stiffness of the flange to hold against the steam pressure. The engineer had noticed a leak, but with the safety valves located as they were and the whole covered up with asbestos and sheet iron, he naturally attributed the leak to the safety valves and was in ignorance of the true state of things. A piece of the sheet-iron covering was found about 150 feet away, but the safety valves were never found.

R. Cederblom.

Gary, Ind.

Trouble with a Synchronous Motor

In the issue of June 30, O. A. Webster tells of his troubles with a synchronous motor. I think he had a partial short-circuit in his armature from the start, and this was the cause of the ammeter variation. He might have had a good deal more than 30 amperes on the fuses, for a fuse will not blow under about 1.7 times its rated carrying capacity. I have run 133-cycle machines a good deal, and experimented with them, using lamps on transformers for paralleling, but without much success. The general verdict is, I think, that the high-cycle machines are not at all desirable to use in this way.

V. L. Ballou.

Shirley, Mass.

Accident to a Vertical Engine

Following is an account of an accident to a large vertical engine. The receiver trap discharged in a line which collected the live-steam drips from the steam header, separators, etc., and led to the hot-well. Some of the valves leaked enough to cause a back pressure on this line. The receiver pressure was very low (about the same as atmospheric), due to light load. The result was that the receiver filled with water until it was carried along with the steam to the low-pressure cylinder. The water all went to the lower end of the cylinder and the sound produced was like a heavy blast in a stone quarry.

The two 4½-inch foundation bolts which held the main cap were pulled up enough to let the field of the generator rub its armature. (The clearance around the generator field was about ½ inch and the generator was near the center of the shaft.) The force involved was considerable, as the shaft above weighed 65 tons and the fly-wheel 150 tons, to say nothing of the field and reciprocating parts. Fortunately, no parts were broken and the bolts were made solid again by "grouting in" from the top. This illustrates the necessity of a free discharge for steam traps.

C. S. Orton.

Rock Hill, S. C.

Which End Does the More Work?

After reading over A. C. Waldron's letter, on page 1037 of June 30 issue, I have come to the conclusion that he is wrong in crediting the work of the condenser to the end of the cylinder connected to the condenser.

The question which he starts out with is: "Which end is doing the more work?" Mr. Waldron's line of argument would be perfectly correct if the question had been: "Which *stroke* is doing the more work?" I think the practical and logical way to solve the problem is to run the engine "one end at a time, condensing and non-condensing, taking cards at intervals to determine the horse-power developed; it will then be an easy matter to find which of the two is doing the most work. Besides this, all the power derived from the use of a vacuum should be credited to the end of the cylinder which furnishes the steam for the creation of that vacuum.

R. MANLY ORR.

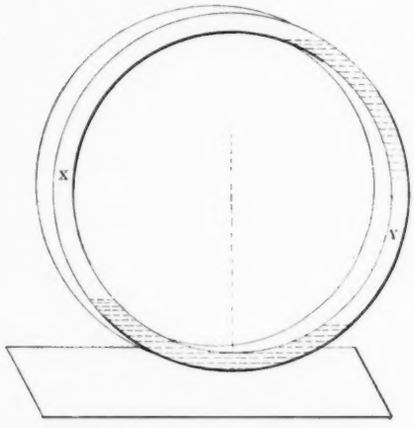
Brantford, Ont.

Perpetual Motion

In the June 23 number, O. A. Benkendorf submits a diagram and asks if it is perpetual motion; also, if the mercury balances the water, or the water unbalances the mercury side of the ring and produces motion; or will they remain stable and unbalanced, and if so, why?

To the first, I would reply "no," for there would be no motion, perpetual or otherwise. To the second I would answer "neither."

To illustrate: Suppose the water on the *Y* side outbalanced the mercury on the *X* side. Then the mercury would creep up toward the point *X*, the level of



THE RING WILL REMAIN AT REST

the water falling toward the point *Y* until they balance each other, and *vice versa*, when they will remain stable and balanced. The ring will remain at rest, due to the law of gravitation.

J. L. BRADSHAW.

Memphis, Tenn.

Lubricating Step Bearings of Curtis Turbines

I wish to say a few words in connection with E. D. Dickenson's answer to my comments, in the July 7 number, upon Mr. Johnson's turbine articles. The machines in question may have left Mr. Dickenson's observation equipped with tanks for the lubrication of the upper and middle bearings, but in a great many cases the little tank got lost in the shuffle.

The loose-sleeve type of bearing has been installed in about as many plants using the central-oiling system for upper- and middle-bearing lubrication as in plants where this lubrication was accomplished by the small tank. The conditions remain about the same today; that is, the loose-sleeve type of bearing has been removed and replaced by solid-type bearings in about as many plants which still continue to use the small tank for lubrication as in plants using the central-oiling system for this lubrication.

C. W. E. CLARKE,
Steam Engineer,
N. Y. C. & H. R. R. Co.

New York City.

Burning Wood Under Boilers

In the early days of the portable engine, wood was used as fuel more generally than at present in wheat threshing and sawmilling, especially the latter. I have often been called to the fields and the woods to make repairs. It was generally the case that most everything connected with the engine would be in a dilapidated condition, owing to the class of men employed as engineers. About the extent of information gained in answer to questions on arriving at the plant would be that they could not get enough fire in the furnace to hold steam and do any work.

It got to be a rule, among other things done to get the plant in running order, to block the grates all around the inside of the furnace, about 4 inches from the water leg, with brick placed flat, or strips of sheet iron about 4 inches wide, with soft mud put on top to prevent the cold air from entering between the grates and the water leg. This was always the means of a large saving in fuel and labor.

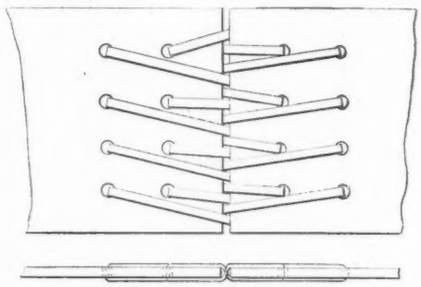
The writer has designed furnaces for portable boilers constructed for sawmill work, and for burning wood, in which the water leg was made very low, the grates placed as low as possible, with the door hole as high as the crown sheet would permit. In such a deep furnace it was of advantage to block the grates around the edge next to the water leg in order to force the air through the body of the fire.

S. A. SMITH.

Henderson, Ky.

Method of Lacing Belts

The accompanying sketch shows my method of lacing belts. I have one rubber belt, 12 inches wide, laced in this way, which runs over 24-inch pulleys making 180 revolutions a minute and transmits



MR. WALLING'S LACING

about 30 horsepower, and it has not been touched for nearly three years. I consider this a good record.

W. A. WALLING.

Edmeston, N. Y.

The Question of Smoke

A very interesting account of the third annual anti-smoke convention in Cleveland recently appeared in the columns of POWER AND THE ENGINEER, and as Washington was not represented there, the writer feels sure that a brief comment upon the conditions in Washington will be of interest.

The great number of white buildings occupied by the various departments of the Government render the emission of black smoke particularly objectionable.

The erection of several new and magnificent white buildings within the last year has been part cause for the increased clamor of public sentiment against smoke, even calling down the maledictions of the President. Accordingly, within the last year there has been a rousing crusade against smoke. A number of inspectors are on duty. The standard of unlawful emissions is smoke so black or thick that the observer cannot distinguish telephone poles, steeples, etc., through it. Of course, care must be taken to view the smoke from a point at the side and not in the direction in which the wind is carrying it. A period of one minute is the requisite for conviction. This impresses one as bordering on the ridiculous. The humor is all out of it, however, when, as has been the case of some concerns, the fines have run up into the hundreds of dollars.

One power house where there are several boilers, and where the load at times demands that they be forced, met the conditions and stopped the fines by securing a skilled boiler-room superintendent.

EDWARD T. BINNS.

Philadelphia, Penn.

Pressure of the Atmosphere on Liquids

Conditions of Equilibrium in Liquid Columns of the Same and Different Densities; Pressure upon Immersed Bodies and Siphonage

BY FRANKLIN VAN WINKLE

A body is said to be in equilibrium when the resultant of all forces acting upon it produces a condition of rest. If from any cause there is a greater pressure exerted upon one point than upon other parts of a liquid, particles will flow from the higher to the lower points of pressure in reëstablishing equality of pressure and

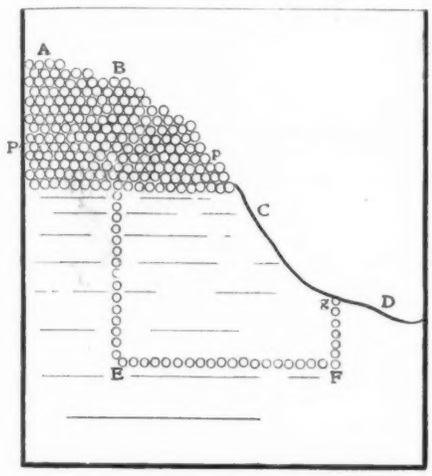


FIG. 1. LIQUID MASS UNBALANCED LATERALLY AND VERTICALLY

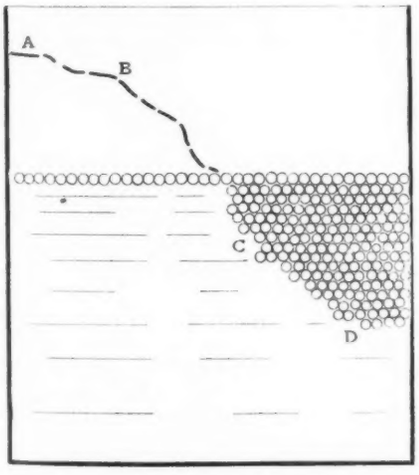


FIG. 3. SURFACE PARTICLES IN HORIZONTAL PLANE AND EQUILIBRIUM ESTABLISHED

equilibrium of the liquid mass. As a consequence, if a quantity of liquid is confined in a vessel, its surface to be at rest must be horizontal. For if it has any other form, as $A\,B\,C\,D$, Fig. 1, a column of particles, as $A\,P$, exerting pressure at P, is unbalanced laterally by horizontal layers of particles like $P\,p$, or vertically by the difference in hights of columns like $B\,E$ and $F\,g$. In absence of an equal and contrary pressure to hold the surface particles in their position, as shown in Fig. 1, they are pushed laterally and upward as shown by the changed positions of p and g in Fig. 2. This action takes place simultaneously over the whole surface, the depressed portion $B\,C$ being filled or raised as rapidly as the change of form can be accomplished by gravity acting on the elevated portions of the liquid, until both lateral and vertical equilibrium have been established. This can only be after the surface particles have arranged themselves in a horizontal plane, as shown in Fig. 3.

Equilibrium in Communicating Vessels

When vessels of any given shape or size are in communication, and each contains liquid of the same density, there will be equilibrium when the surfaces of the liquids in each of the vessels are on the same level. Suppose the vessels A, B, C, D and E, Fig. 4, to communicate with each other by means of the pipe $P\,p$. Then considering any cross section of this connecting pipe as at s, equilibrium can exist in this section only as long as the pressure from P toward p equals the pressure from p toward P, and the same will be true of any other section. Pressure from A toward E may be considered as counterbalancing the pressure from E toward A and the vertical-column pressure due to B, C and D may each be considered as counterbalancing the upward pressure in the pipe P. The pressure at any section of P is equal to the weight of a column of the liquid whose base has the same area as the section and whose hight is measured vertically from the center of pressure of the section. In order for this to be so, the same vertical-column pressure must be produced in the connecting pipe P on all sections which are at the same level. It therefore follows that, for equilibrium there must be equal column pressures from all the connecting vessels, i.e., the surfaces of liquids

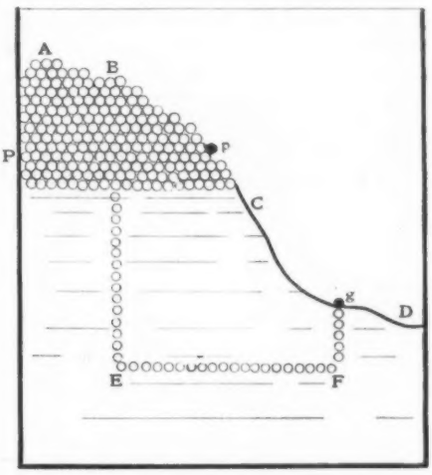


FIG. 2. GRAVITY ESTABLISHING EQUILIBRIUM

in each of the vessels must be on the same level.

Equilibrium of Liquids of Different Densities

It must be evident from the foregoing that if liquids of different densities are placed in the different vessels, the relative hights of the columns will vary and equilibrium will be established in the connecting pipe P by dissimilar levels, according to the densities of the liquids.

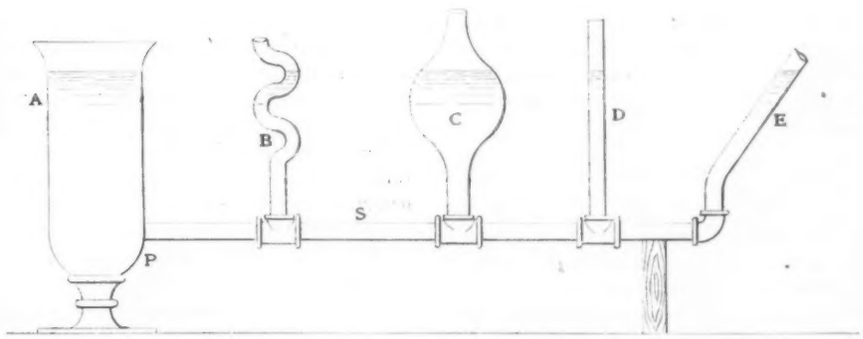


FIG. 4. SURFACE OF WATER COLUMNS AT SAME LEVEL

Fig. 5 represents the same apparatus as Fig. 4, differing only in having a stop

cock placed in each of the vessels *B*, *C* and *D*, near its point of junction with the connecting pipe *P*. With these stop cocks closed, we will suppose the connecting pipe *P* and vessels *A* and *E* to be filled with water to a hight of about 14 inches above the level of the stop cocks. It is evident that equilibrium in the pipe *P* will be destroyed by opening the stop cocks, unless the upward pressure at the stop cocks is counteracted by an equal downward pressure. This pressure may be created as before by filling all the vessels with water to the same level, or we may fill each with liquids of any density to a sufficient hight to create the same hydrostatic pressure as that created by the water in the vessels *A* and *E*. The weight of mercury being 13.6 times that of water, 1 inch depth of mercury in one of the vessels, as *D*, would result in pressure equal to 13.6 inches of water, while olive oil, being about 92 per cent. the weight of water, will have to be filled in one of the vessels, as *C*, to a hight of about 14¾ inches; and sulphuric acid, with a specific gracity of 1.85 times that of water, introduced

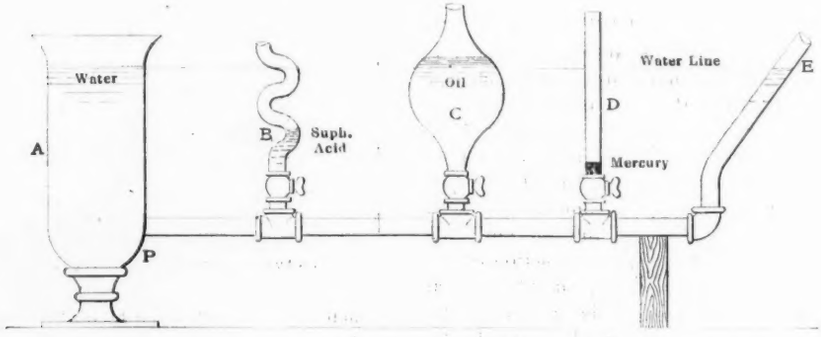


FIG. 5. BALANCING LIQUID COLUMNS OF DIFFERENT DENSITIES

into one of the vessels, as *B*, would have to be filled to a hight of about 7⅜ inches.

Having filled the different vessels to the respective hights, the stop cocks may be opened without disturbing the relative hights of the liquids, as the downward pressure from each will balance the upward pressure from the connecting pipe *P*.

Hights of Balanced Columns are Inversely as the Densities

The hights above the horizontal surface of contact of two columns of liquids in equilibrium are inversely as their densities. To show this experimentally, mercury is poured into a bent glass tube *M N*, Fig. 6, fixed against an upright wooden support, and then water is poured into one of the legs *A B*. The column of water *A B* pressing on the mercury at *B* lowers its level in the leg *A B* and raises it in the leg *C D*. If, when equilibrium is established, we imagine a horizontal plane *B C* to pass through *B*, the column of water in *A B* will balance the column of mercury *C D*. Upon measuring the hights of these two columns, it will be found that the hight of the column of water *A B*, is about 13.6 times that of the column of mercury, measuring upward from the same level *B C*. The density of mercury is about 13.6 times that of water, from which it follows that the hights are inversely as the densities.

Again referring to Fig. 6, it will be readily understood that if the column *A B* is of uniform size, then the weight of the water column *A B* will be the amount of pressure exerted by the water in *A B* upon the surface of the mercury at *B*, and that the pressure on *B* will be directly in proportion to the hight of the water column in *A B*.

Pressure Due to Head

We have seen, however, that the same intensity of pressure on the liquid surface *B* results from the same vertical hight or head of liquid above *B*, regardless of whether the containing surface above *B* is a straight tube or of any other size or form, such, for instance, as is shown in Fig. 4.

It therefore follows that pressure to which the surface of a liquid is exposed, can be measured by the hight or head of liquid column which that pressure can support.

The truth of this principle is of the greatest convenience in practical estimates and computations, from the fact that nearly all questions in hydraulics involve considerations both of pressures and differences of level. It is therefore customary in practical hydraulics to express pressures in feet of head, meaning thereby actual or equivalent pressure of a column of water of given hight or head acting on a unit area of surface.

In ordinary computations, the weight of a cubic foot of water is taken at 62.5 pounds. As indicated in Fig. 7, a cube of water, 12x12x12 inches, may be considered as divided into 144 columns, each 1 foot high with a base 1 inch square. The pressure due to a column of water 1 foot high, with a base 1 inch square, is therefore

$$\frac{62.5}{144} = 0.434$$

pound. Consequently, the hydrostatic pressure of water is 0.434 pound per square inch for each foot of head. When it is desired to find the pressure in pounds per square inch due to any given head, we have simply to multiply the head, measured in feet, by 0.434; for example, the

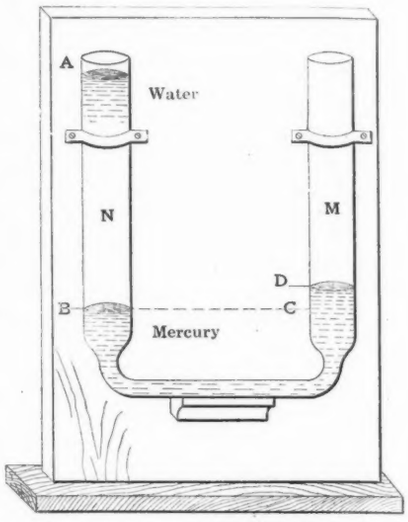


FIG. 6. BALANCING COLUMNS OF MERCURY AND WATER

pounds pressure per square inch resulting from a 50-foot head of water, would be

$$50 \times 0.434 = 21.7$$

pounds per square inch.

Lateral Pressure

It should be readily understood that the pressure on each horizontal layer of a vertical column of liquid is directly in proportion to its depth. Now as the intensity of pressure from any particle is the same in every direction, it follows that with a given hight of column, as *A B C D E*, Fig. 8, lateral pressures *A a*, *B b*, *C c*, *D d* and *E e* will be the same per unit of area as the vertical pressure on the corresponding horizontal layers of the column at the same depths.

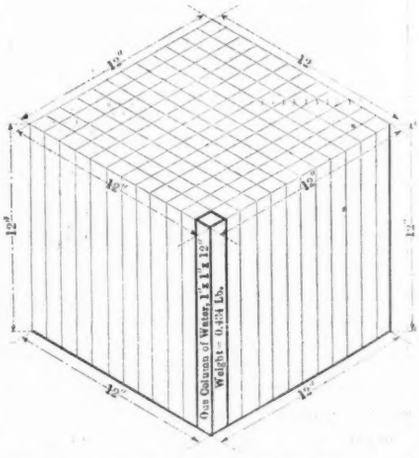


FIG. 7. ONE CUBIC FOOT OF WATER DIVIDED INTO 144 COLUMNS, 1X1X12 INCHES

If *A E* is assumed to be a tube filled with water, every point on each side of

the tube will be subjected to a pressure directly in proportion to the head, that is to say, a point in the side of the tube acted upon by a head of 1 foot, would have to resist pressure of the intensity of 0.434 pound per square inch; and by a 50-foot head a pressure of

$$50 \times 0.434 = 21.7$$

pounds.

Pressure Upon an Immersed Body

When a solid is immersed in a liquid, every portion of its surface is subjected to pressure which increases with the depth of the liquid.

Imagine a cube to be immersed in a mass of water, Fig. 9. Opposing pressures on the four sides are evidently in equilibrium. Considering the pressures exerted on the upper and lower faces *A* and *B*, we can readily understand that downward pressure on the upper face *A* will amount to the same thing as the downward pressure of a column whose base is *A* and whose head is *A D*. The lower face *B* is pressed upward with the same intensity as the weight of a column having the hight *B D* and base equal to the lower face *B* of the cube. The cube is, therefore, urged upward by a force equal to the difference between these two pressures, that is to say, the upward pressure is equal to the weight of a column of water the size of the cube itself. Otherwise expressed, upward pressure is equal to the weight of the volume of water displaced.

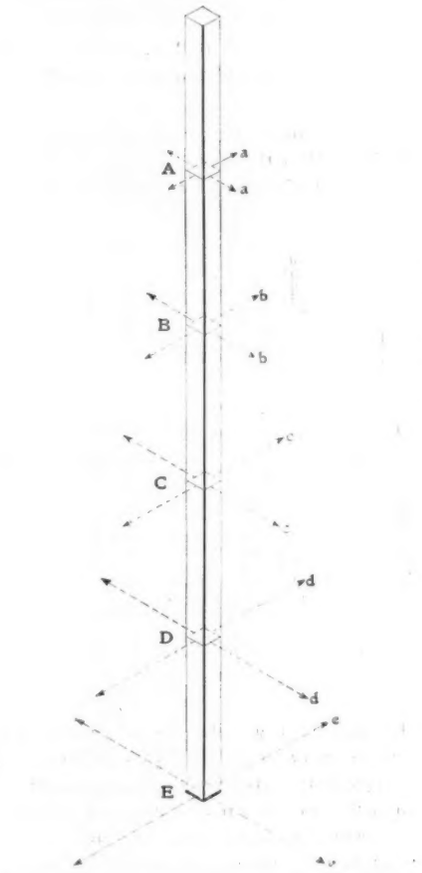


FIG. 8. LATERAL AND VERTICAL PRESSURES EQUAL

Thus, it becomes evident that every body immersed in a liquid is pressed upward

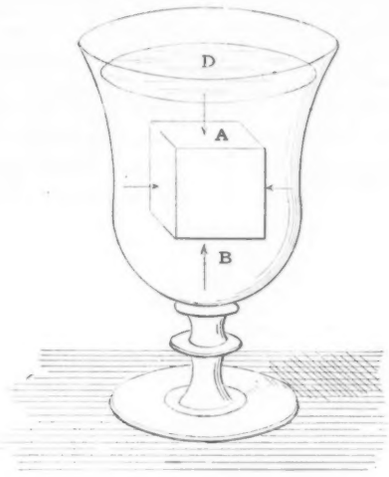


FIG. 9. CUBE IMMERSED IN WATER

by a force equal to the weight of the displaced liquid; for, suppose a portion of the liquid to become solidified in any given shape without change of volume, as *C* in Fig. 10. The solid thus formed will remain at rest and would therefore have to be acted upon upward by a force just equal to its weight. If, in place of the solidified water *C* we substitute any other liquid or solid substance occupying the same space, it would receive the same pressures from the surrounding liquid as the solidified portion had received, and would be subjected to the same upward

FIG. 10. IRREGULAR OBJECT IN WATER

pressure as the equal volume of solidified liquid had received, that is to say, equal to the amount of liquid displaced.

The preceding principles prove that whenever a body is immersed in a liquid, it is subjected to two forces, viz., gravity, which tends to lower it, and buoyancy of the liquid, which tends to raise it with a force equal to the weight of the liquid displaced. So that when a body is immersed in a liquid, it loses part of its weight equal to the weight of the displaced liquid. This principle, named after the discoverer, is called the principle of Archimedes. It may be determined experimentally with the appearance shown in Fig. 11.

An open barrel, provided with an outlet and stop valve *V* near the bottom, is placed on a platform scales and partly filled with water, as for instance to the level indicated by the dotted line *A*. The level of water is then to be marked by driving three or more small nails around the inside of the barrel at the surface of the water at approximately equal distances apart. The gross weight on the platform scales is then noted. Any solid

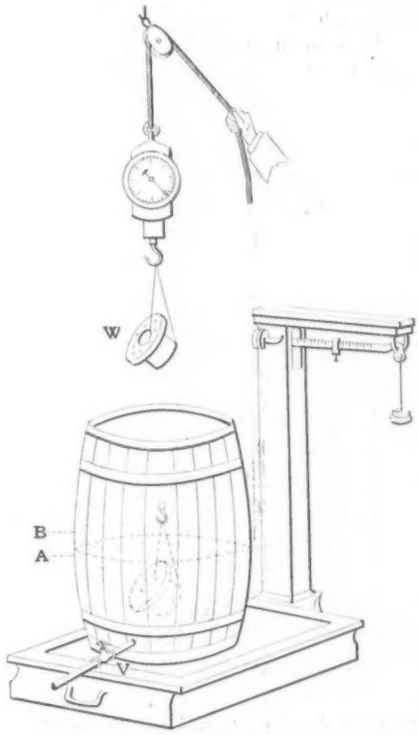


FIG. 11. BUOYANCY EQUALS WEIGHT OF WATER DISPLACED

mass of material, as *W*, is then suspended in the air from a spring balance, as shown in the figure, and its weight noted. Then, with *W* still suspended from the spring scales, the latter is lowered until *W* is submerged in the water contained in the barrel below the original level *A*.

As soon as any portion of the mass *W* becomes submerged, the spring scales will be found to indicate less weight from *W* than when suspended in the air. Another thing observable is that as *W* becomes submerged, the water contained in the barrel gradually rises until *W* is completely submerged. Suppose, when complete submergence of *W* takes place, that the level of the water has risen to the level *B*; then the volume of water between the levels *A* and *B* will evidently be the volume of water displaced by *W*.

Now, with W still suspended under water, note the weight shown by the spring balance and also note the new weight shown on the platform scales. It will be found that the spring scales has lost precisely the same weight that the weight on the platform scales has increased. If water is now discharged from the barrel by the valve V until its level is reduced to the original level A, with W still submerged, the weight indicated by the platform scales will be found to be the same as originally indicated. Then, upon withdrawing W from the barrel, the weight on the platform scales will be found to be as much less than the original weight, as the difference in weight of W when weighed in air and when weighed in water. This difference in weight is the buoyant effect of the water, which is just equal to the weight of the volume of water which was displaced by the body W.

As a small discrepancy is liable to be introduced in the above comparisons of

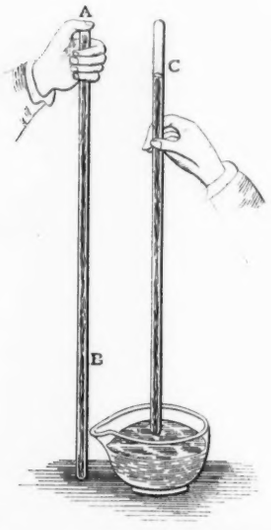


FIG. 12. TORRICELLI'S EXPERIMENT

weights due to unequal displacements of water by the cord or rope by which W is suspended, each time W is suspended for the purpose of observing weights with W submerged, the same amount of cord or rope should be submerged below the surface of the water in the barrel.

Influence of the Atmosphere

Both by its pressure and mixture with liquids, the atmosphere exerts such important influences over the pressure and flow of liquids as to require special consideration. By the following experiment, Torricelli, while a pupil of Galileo in 1643, was the first to make an exact demonstration of the pressure exerted by the atmosphere. His demonstration of this is as follows:

Referring to Fig. 12, a stout glass tube $A\,B$ about 36 inches long, sealed at one end, is nearly filled with mercury. The open end A being closed by the thumb, the tube is inverted, the open end placed in a mercury trough and the thumb removed. The tube being held in a vertical position, the column of mercury sinks, and after oscillating up and down in the tube for a short time, the mercury finally comes to rest at a hight C. When the experiment is performed at the level of the sea, the hight of the column of mercury will be about 30 inches above the level of the mercury in the trough. The column of mercury is sustained in the tube by the pressure of the atmosphere on the mercury in the trough. There is no downward pressure on the upper surface

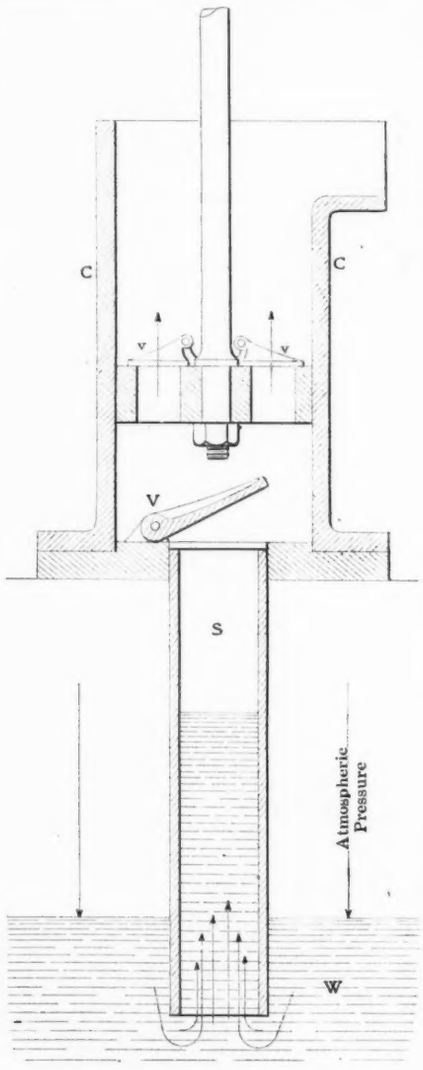


FIG. 13. ORDINARY SUCTION PUMP

of the mercury, because the tube is closed. Should the upper end of the tube be opened, the atmosphere would press equally inside and outside the tube and the mercury would sink to a common level with the mercury in the trough. We have already seen that the hights of two columns of liquid in communication with each other will be inversely as their densities, hence it follows that at sea level the pressure created by the atmosphere will be the same as that of a column of mercury about 30 inches high.

If we measure the hight of such a column of mercury from time to time, we find that it varies according to the condition of the atmosphere. As we carry this apparatus to places of higher elevations above sea level, we find that the liquid column settles to a less hight, indicating, as it should, less pressure of the atmosphere. This is the principle of operation of the mercurial barometer.

It has been demonstrated that the pressure of the atmosphere will sustain a column of water or any other liquid in the same manner, but the hights of the columns so sustained will be inversely as the densities of the liquids. Mercury is 13.6 times the weight of water, so at sea level a column of water should rise to a hight of

$$30 \times 13.6 = 408$$

inches, or 54 feet under pressure of the atmosphere, which Torricelli found to be the case.

The pressure per square inch which will be created at the foot of a column of mercury 30 inches high, will be the same as

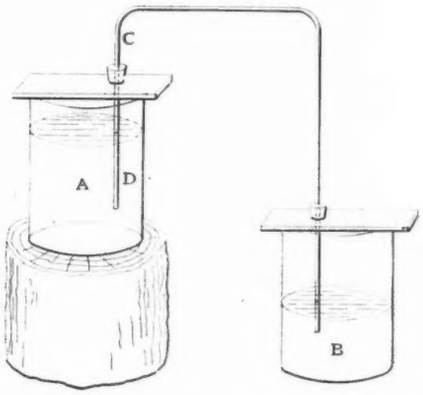


FIG. 14. SIPHONING FROM A HIGHER TO A LOWER LEVEL

the weight of 30 cubic inches of mercury. This is very nearly equal to 14.7 pounds, therefore the pressure of the atmosphere, in order to sustain a column of mercury 30 inches in hight must amount to 14.7 pounds per square inch, and this is the pressure per square inch actually considered due to the atmosphere. But when the pressure of the atmosphere is to be taken into account for a place whose elevation is considerably above sea level, or where the hight of the barometric column has considerable deviation from 30 inches, proportionate values are also to be taken for the pressure of the atmosphere and the hight of a column of water which would be sustained by the atmosphere.

The action of atmospheric pressure on the free surface of liquids is well illustrated in the operation of an ordinary suction pump, and may be readily understood by referring to Fig. 13. In the figure, $C\,C$ represents a pump cylinder with an inlet valve V opening inward and piston with one or more valves $v\,v$, also opening upward. In the beginning of the opera-

tion, when the piston is drawn upward, the valves $v\,v$ in the piston are closed by the pressure of the atmosphere and a partial vacuum is formed below the piston. Relief of pressure from the top of the valve V causes it to rise on account of the presence of full atmospheric pressure of air in the suction pipe S, resulting in reduction of pressure in S. Full atmospheric pressure simultaneously acting on the surface of the water W, causes the water to rise in S until equilibrium is established, which will be when the pressure due to the hight of the water in the suction pipe combined with the pressure on top of the column is equal to the atmospheric pressure acting on the surface of the water W.

When the piston descends, the valve V will close, while the valves $v\,v$ in the piston will open and allow the air in the space below the piston to escape. Thus it appears that each double stroke of the piston removes some air from the cylinder, thereby lessening the pressure above the liquid column in S, causing it to rise higher and higher from the action of the atmospheric pressure on W, until it finally fills the lower part of the pump cylinder and is discharged continuously in the same manner as the air was discharged in the beginning.

In the beginning of operation of the suction pump it is impossible to create a perfect vacuum by the removal of all air pressure from the top of the liquid column. The hight of liquid column raised in the suction pipe S by the pressure of the atmosphere on W can, therefore, never be equal to the hight of liquid column which, acting without superimposed pressure, would be equal to the pressure of the atmosphere.

When pressure of the atmosphere is capable of sustaining a mercury column 30 inches high, we have seen that this pressure will be equal to the pressure of a column of water 34 feet in hight. Consequently, when the barometric reading is 30 inches or less, atmospheric pressure would not force water above the valve V into the space above the piston unless the vertical distance of V is less than 34 feet above the surface of W.

Siphonage

In its simplest form the siphon consists of a U-shaped tube by means of which water or other liquids may be conveyed by atmospheric pressure from a given level, over a higher elevation, to a lower level, as from vessel A to vessel B, Fig. 14. The usual method of setting the siphon in action is to fill the tube with the liquid, close the ends and place the shorter branch or leg in the vessel to be emptied, and then open the ends, when flow will ensue from the higher to the lower level, and will continue as long as the liquids in the two vessels are at different levels and the leg $C\,D$ dips into the liquid. The action of siphonage may be better understood from the following considerations:

If, in Fig. 15, the U-shaped tube $A\,B\,C\,D$ first filled with water, is afterward erected with its ends submerged, water will remain standing in both legs of the U-tube by virtue of atmospheric pressure on the surface of the liquid W. The hight at which the water will stand will not, however, exceed the hight of a column which will produce pressure in excess of the pressure of the atmosphere. With ordinary pressure of the atmosphere, two columns of water $E\,F$ and $G\,H$, each 34 feet high, could be sustained above the surface of the water W, the space in the tube above the levels of F and H being a vacuum.

By raising the level of the water in W, it is evident that the liquid columns would rise until they completely filled the vacuum space $F\,J\,H$, the pressure at J being zero, as before. By further raising the level of the water surface W, as shown in Fig. 16, each of the columns would have a hight less than the hight of column capable of being supported by atmospheric pressure on the surface of the water W. Nevertheless, upward pressure in the legs at the new surface of W would be equal to the pressure of the atmosphere, to balance which there must be an equal downward pressure from the columns. The hight of column being less than necessary to produce this downward pressure, equilibrium can exist only by virtue of pressure within the liquid at the crest of the bent portion J, to make up the difference between the pressure due to the hight of a column like $E\,F$ or $G\,H$, in Fig. 15, and the pressure due to gravity of a column having a vertical hight of the crest J above the surface W.

If, as shown in Fig. 17, we place a partition $X\,Y$ through the vessel containing the liquid, and draw down the liquid on one side of the partition to a level $w\,w$, then, from the fact that water in the leg $A\,B$ stands higher above the sur-

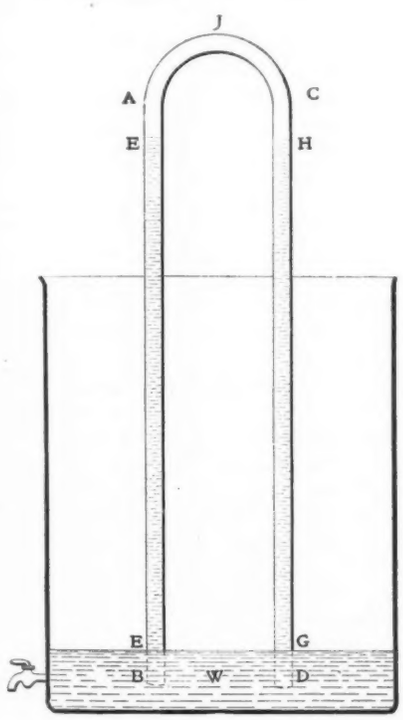


FIG. 15. ATMOSPHERIC PRESSURE SUSTAINING WATER COLUMN 34 FEET HIGH

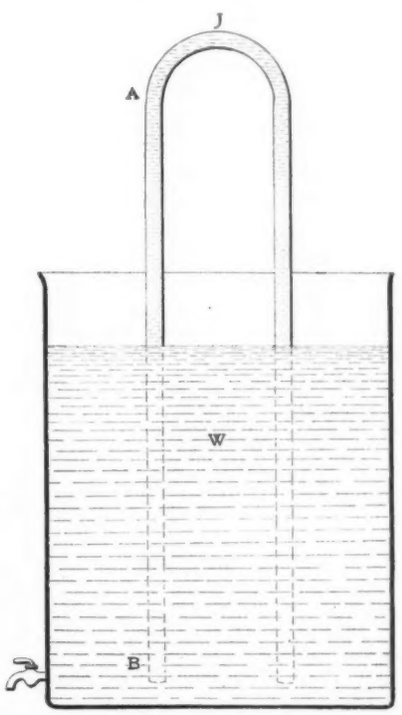


FIG. 16. PRESSURE IN BOTH LEGS BALANCED

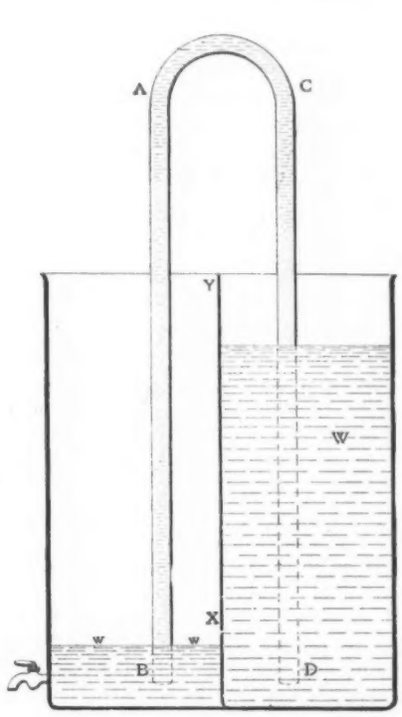


FIG. 17. UNBALANCED PRESSURE

face $w\,w$ than water in the leg $C\,D$ stands above the surface of W, it follows that pressure due to gravity of the column $A\,B$ will be greater at the surface $w\,w$ than the pressure due to gravity of the column $C\,D$ at the surface of W. In consequence of this there will be less pressure within the upper end of $A\,B$ to help balance atmospheric pressure at $w\,w$, than in the upper end of $C\,D$ to help balance atmospheric pressure at the surface of W. Hence, flow will take place from the leg $C\,D$ over to the leg $A\,B$, being due to the fact that the pressure from C to A is greater than the pressure from A to C, their difference in pressure being equal to the pressure which would be created by a column whose hight would extend from the level of the surface $w\,w$ to that of the surface of W.

It follows, therefore, that the elevation over which a liquid can be siphoned cannot exceed the hight of a column of that liquid which the atmospheric pressure will support; and also that the pressure which produces siphonage will depend upon the difference in level of the liquids in the two vessels.

Engineers' Examination Questions

Following is a set of engineers' examination questions selected at random from a great number of questions which have been recently submitted to POWER AND THE ENGINEER by contributors, who desire us to answer them. This we intend to do, eventually; or at least we will answer those which are left unanswered by our readers, who are invited to contribute answers to or comments upon the questions, as they may desire.

1. It is desired to carry 125 pounds steam pressure on a horizontal tubular boiler 16 feet long by 66 inches in diameter.

(a) What thickness of plate would you use in the shell of this boiler, assuming a tensile strength of 60,000 pounds per square inch in the plate?

(b) What thickness of plate would you use in the heads of this boiler, assuming the strength of the plate as 60,000 pounds per square inch?

(c) What type of girth joints and longitudinal joints should be used and what is the strength of the plate?

(d) How many braces should be used in this boiler and what is the strain per square inch that you should allow the braces?

(e) Where should the water-column, steam and feed-water openings be located?

(f) How should a dome, 30 inches in diameter by 30 inches high, be constructed and attached to this boiler?

2. How would you inspect a new boiler?

3. How would you inspect the same boiler after it had been in service two years?

4. Name the various types and kinds of boiler liable to be found in use in the city of Detroit.

5. What are the particular points in each of the above types which should receive especial attention when these boilers are inspected?

6. What parts of a boiler may be safely constructed of cast iron and what steam pressure, under such construction, would you allow to be carried on said boiler?

7. In case you found a boiler or appliances in an apparently unsafe condition, what would you do about it?

8. What would constitute satisfactory examinations for first-class, second-class and third-class engineers' licenses?

9. How often should boilers be cleaned in the city of Detroit? Is there any difference between the summer and winter seasons?

10. Would you recommend the use of any solvents or compounds to prevent scale formation in boilers? If so, how should this compound be used?

11. What precaution would you suggest in laying up a boiler?

12. Give formulas for estimating safe working pressure and bursting pressure of tubular boilers and drums of water-tube boilers.

13. Give the formula for estimating safe working pressure and bursting pressure of flat surfaces, such as fire boxes of fire-box boilers and water legs and tube headers on water-tube boilers, etc.

14. If stay bolts are 4 inches from center to center, with 100 pounds gage pressure what would be the steam pressure on each stay bolt?

15. What is the value of a hydrostatic test on a boiler; how much above working pressure should such a test be made? Why?

16. How long should this test pressure be maintained?

17. Would you use hot or cold water for such a test? Why?

18. What examination should be made of a boiler after applying such test?

19. Which should be next to the boiler, a globe valve or a check valve?

20. Where should a blowoff pipe be attached to a boiler?

21. Name four different kinds of braces in a boiler and describe each, telling where used, etc.

22. What parts in a boiler are first affected by low water?

23. What is a pressure gage used for, and does it contain water or steam?

24. What kinds of boiler are mostly in use? Describe them.

25. What is the space called in which combustion takes place?

26. What is a butt joint and what is a lap joint?

27. What is a safety valve for?

28. What is a steam gage used for?

29. If your boiler were foaming, how would you remedy it enough to keep on running, without shutting down the plant?

30. What is priming, and what is the cause of it?

31. What will sediment in a boiler cause?

32. If you should step into your boiler room and the steam gage showed 40 pounds more pressure than the usual blowoff pressure, what would you do?

33. Give two causes of the water glass not showing the true level of the water in the boiler.

34. What causes boilers to bag? How would you prevent it?

35. If the water in the gage glass should drop out of sight, what would you do?

36. Which part of a horizontal return-tubular boiler is first endangered by low water?

37. Diagram a separator and explain it.

38. What pressure can you get with a pump having a 7½-inch steam piston and a 5-inch water piston, with 80 pounds gage pressure?

39. If a pump will force water 100 feet upward, how far will it force it to add a 20-foot suction lift?

40. How far will a pump draw water, vertically and horizontally?

41. Why will not a pump lift hot water?

42. Should a pump become steambound several times in a day, how would you remedy it?

43. What is the difference between a single- and a double-acting pump?

44. What is the least number of valves required in the water end or the water cylinder of a duplex pump?

45. Which pipe in a pump should be the largest, the suction or the discharge pipe? Why?

46. Which piston should be the largest in a boiler-feed pump, steam or water, and why?

47. What is the advantage of the suction chamber on a pump?

48. What causes the water to flow into the cylinder of a pump from a source below the pump?

49. Where would you place the globe valve on the discharge line of a boiler-feed pump, and why?

50. How would you give a steam valve on the engine more lead?

51. What effect has increasing the lead on the various operations of the valve?

52. How would you increase the speed of an engine?

53. What is a horsepower? Give the rule for finding the horsepower of an engine.

54. Give two methods for increasing the horsepower of an engine.

55. What benefit is derived by using a flywheel on a steam engine?

56. Describe the operation of a compound engine.

57. What is a receiver of an engine?

58. Why are condensers attached to a steam engine?

59. Explain how an engine passes over dead center?

60. What is compression?

61. What is the travel of a valve?

62. How would you equalize the piston clearance in an engine cylinder if the rod is keyed to the crosshead?

63. How many working edges has a plain slide valve?

64. Give in full all you would do in getting ready to start and operate a steam plant, consisting of boilers, engines, pumps and feed-water heater and all piping, after it had been shut down for one year?

Catechism of Electricity

The Transformer Booster

742. *How can the drop in voltage in an alternating-current circuit be compensated?*

One method is to use a transformer "booster," connected as shown diagrammatically by Fig. 258. The high-tension winding *h* is connected across the mains near the generator *a* and the low-tension winding *m* is connected in series with one of the line wires, *c e*. The connections are made so that the direction of current flow at any instant is the same in the secondary winding of the transformer as in the line wire. This is indicated by the arrows in the diagram.

743. *How does this arrangement compensate for the drop in voltage?*

The voltage induced in the secondary winding of the transformer is added to that of the generator. For example, suppose the generator to be giving 2300 volts at its terminals and the drop in the line to be 115 volts. If a transformer having a ratio of 20 to 1 be connected as shown in the diagram, its secondary voltage will be 115 volts, and this will be added to the voltage of the generator. Consequently, while the voltage from *b* across to *c* will remain 2300, the difference of

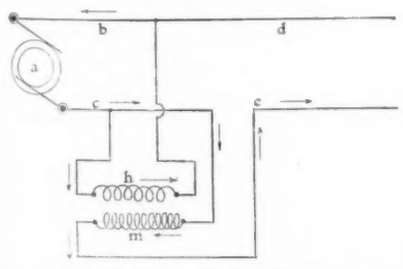


FIG. 258. DIAGRAM OF CONNECTIONS OF A TRANSFORMER-VOLTAGE BOOSTER

potential between *d* and *e* will be 2300 + 115 = 2415 volts. This will make up the drop of 115 volts in the line and raise the voltage at the far end to equality with the generator voltage of 2300.

744. *Can this method be applied to two-phase circuits?*

Yes; Fig. 259 is a diagram of booster connections for a two-phase circuit. It is merely a duplication of the arrangement shown in Fig. 258, the two-phase circuit being the exact equivalent of two single-phase circuits.

745. *What are the disadvantages of this method of compensating for the voltage drop in a line?*

The chief disadvantage is that the boosting transformer raises the voltage by practically the same amount at all loads. Consequently, the voltage at the end of the line is too high at small loads. This can be corrected, however, by making the transformer adjustable as to ratio; the secondary winding can be divided into a large number of sections and the terminals carried out to a switch by means

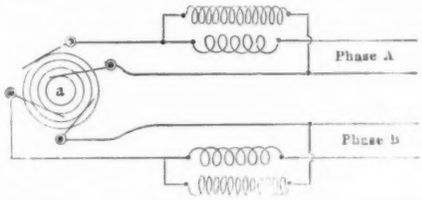


FIG. 259. CONNECTIONS OF A TRANSFORMER BOOSTER ON A TWO-PHASE CIRCUIT

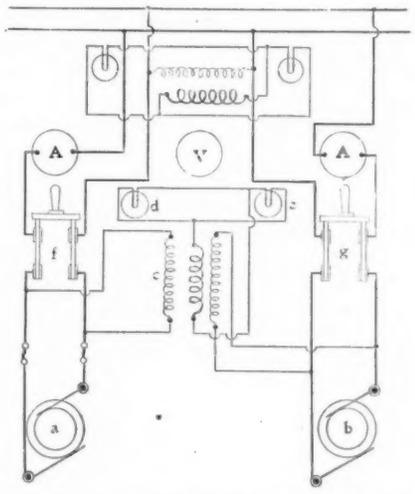


FIG. 260. SWITCHBOARD WIRING FOR TWO SINGLE-PHASE ALTERNATORS OPERATED IN PARALLEL

of which more or less of the winding can be put in circuit, thereby varying the added voltage. This is a rather clumsy method, however.

Another disadvantage is the size and cost of the transformer or transformers. They must have a power capacity equal to that of the generator divided by its smallest ratio of transformation. Thus, if the generator is a 5000-kilowatt machine and the transformer ratio is 10 to 1, minimum, the transformers must aggregate 500 kilowatts capacity.

Switchboard Connections for Parallel Operation of Alternators

746. *How is a switchboard wired for two single-phase alternators to be operated in parallel?*

Fig. 260 shows the principal connections of the switchboard apparatus for operating two single-phase alternators (*a* and *b*) in parallel. At *c* is the synchronizing transformer and at *d* and *e* the lamps, the principle of which has already been explained. The primary windings of the

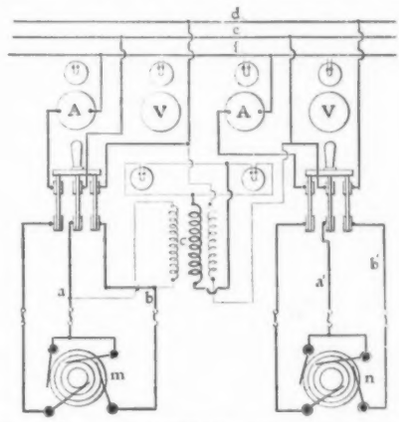


FIG. 261. SWITCHBOARD WIRING FOR TWO TWO-PHASE ALTERNATORS TO BE OPERATED IN PARALLEL

synchronizing transformer are connected in opposition to each other so that the synchronizing lamps, *d* and *e*, will be dark when the machines are in step. Until this condition has been brought about, one of the main switches, *f* and *g*, must be left open. It is always well when the connections are made as in Fig. 260 to have an extra lamp connected in multiple with each synchronizing lamp; then if one lamp be burned out, the other will still indicate whether or not the alternators are in step. Though not absolutely necessary, it is preferable to have a voltmeter for each machine, especially if they are to be thrown together while one is carrying a varying load.

747. *How should a switchboard be wired for operating two polyphase alternators in parallel?*

Fig. 261 is a diagram of the main switchboard connections for operating two two-phase alternators *m* and *n* in parallel. Since there is always a fixed relation between two or more phases developed by the same machine, it is not necessary to employ more than one synchronizer when throwing polyphase machines in parallel. One of the primary windings of the synchronizing transformer is connected to the bus bars *d* and *e* and the other primary winding is connected to the corresponding phase of the alternator *m*. One voltmeter for each machine is sufficient, but the connections should be such that when the two machines are running in multiple there may be one voltmeter on either phase; and that when only one machine is in operation, it may be possible to use either voltmeter in connection with that one machine. It is also best to connect the transformers that feed the pilot lamps and voltmeters between the switches and the alternators so that there may be light and a proper indication of voltage before the switches are closed.

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

Issued Weekly by the

Hill Publishing Company

JOHN A. HILL, Pres. and Treas. ROBERT MCKEAN, Sec'y.

505 Pearl Street, New York.
355 Dearborn Street, Chicago.
6 Bouverie Street, London, E. C.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $4 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 16 Shillings.

Entered as second class matter, April 2, 1908, at the post office at New York, N. Y., under the Act of Congress of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

During 1907 *we printed and circulated* 291,500 *copies of* POWER.

Our circulation for August, 1908, *was (weekly and monthly)* 154,000.

Sept. 1..... 38,000
Sept. 8..... 39,000

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

	PAGE
The Du Bois Tandem Gas Engine	383
A Plant Remodeled	387
Automatic Steam and Ammonia Packings	389
The Purchase of Electric Motors and Accessories	392
The Prevention of Steam Engine Breakdowns	394
The Plunger Hydraulic Elevator	396
Electricity from Peat	398
Gas Compressors of Special Type	398
Liquid Fuel	400
Designing Labyrinth Stuffing Boxes for Steam Turbines	401
Practical Letters from Practical Men: A Live Steam Blower....How a Pounding Engine Was Cured....Placing an Engine on the Center....Thickness of Boiler Plates....An Emergency Pump Repair....Air Leakage in Condensers....Cause of a Pound in a Gasolene Engine....A Compression Argument....Belt Lacing....Home-made Packing....Unequal Points of Cut-off....Novel Method for Renewing Metallic Packing....Points on Engine Erection....Ejectors for Artesian Wells....Thinks Single Flywheel High-speed Engines Would Give Trouble....Cause of a Hot Gasolene Engine....Blow-off Arrangement for Sterling Boiler....Injudicious Advertising....Why the Receiver is Noisy....How an Old Timer Was Improved....A Valve Disk Caused Trouble....Detecting Leaks with the Indicator....What Takes Place When a Boiler Explodes....Trouble with a Synchronous Motor....Accident to a Vertical Engine....Which End Does the More Work?....Perpetual Motion....Lubricating Step Bearings of Curtis Turbines....Burning Wood Under Boilers....Method of Lacing Belts....The Question of Smoke	403-412
Pressure of the Atmosphere on Liquids	413
Engineers' Examination Questions	418
Catechism of Electricity	419
Editorials	420-421

Rewarding Efficient Service

In the municipal electric light and power plant, at Maidstone, Kent, England, a unique method of fixing the value of engineers' services has been proposed by the city council. When the total station cost (not including capitalization) per unit is one and one-eighth pence, the salary of the engineer is to be £300 per year, but for every £100 saved in the cost of current sold a premium of £20 is to be paid to the engineer. It would seem that, with a modern plant, an engineer might be able to increase his salary to an appreciable extent, although the reason why the engineer alone should benefit from the improvements in service and efficiency of men, which can only be brought about by hearty coöperation of the entire station force, is not so obvious. Self-interest is usually the mainspring of human action, and to expect that a subordinate will give his work the best that is in him for no higher reward than to see his chief get a raise in pay, is to expect that which is not probable, and is practically impossible of attainment for any length of time.

In a great majority of cases the semi-skilled laborers in power plants are not treated with the consideration that will insure the performance of duty in the highest possible degree. A notice which is often seen in large establishments reads: "He who does no more than he is paid for will not be paid for more than he does." If the notice read: "He who does more than he is paid for may soon be paid for more than he does," it would have less the character of a blow, and hold out the promise of a possibility of promotion to the ranks of those who are paid for what they are, rather than for what they do.

In any scheme for profit sharing every employee, even to the humblest, should be considered, and the same inducements offered to make his work the best that he is capable of that are offered to the highest-salaried experts in the plant. This proposal on the part of the council of Maidstone is an example which might well be followed by many plant managements in this country, both municipal and private. It would have a tendency to create more of a feeling of community of interests between employer and employee, and is a practice that has been adopted to some extent and success by many manufacturers, but, as far as is known, has never been attempted in power plants, either private or public.

In this country, where there is a growing impression that a municipality can purchase power, light and water from private corporations cheaper than they can be produced under public ownership, an experiment of this kind in a municipal plant would awaken a wide interest in the outcome. It would settle the contention that a man as a public servant is less efficient than as a private servant, and the result of the new departure at Maidstone may have an illuminating effect upon the question.

Progress and the Engineer

The present is preëminently an era of progress in processes and methods, and daily developments are profuse in promises of reduction in labor in manipulation and in the cost of operation. That a large proportion of these promises will fall far short of fruition is certain, but many of permanent value will survive, and in power-plant improvements they are certain to be adopted, in some form, with profit.

While, owing to the comparative novelty of electricity and the internal-combustion motor, in engineering practice, the advancement in these branches seems to be wider and more rapid than in other lines, still in steam and hydraulic engineering such progress is being made that the operating engineer must exert considerable effort to keep abreast of the times. It is highly important that he should know of all that is taking place in his own field, for this field is being invaded, and every step that leads toward economy and improved methods should be thoroughly understood. Whether it be the making of briquets from coal dust, or the improvement of feed-water purifiers, economizers, superheaters or what not, the engineer should be uptodate with all of them. He must know what they are, what they will do and why they will do it. He must also be sufficiently familiar with all of them to decide which are of value anywhere, as well as those which promise a general utility which will be individually worth while. As a steam engineer, it would seem more natural that he should keep a closer watch of heat, power and transmission economies, etc., than advancement in other lines, and, as the refinements of practice become more highly developed, take advantage of every possible aid that promises to end in economy.

If he is to get into and keep in the front rank of successful engineers and is to make a record for reducing running expenses, nothing can be overlooked. If the chances for improvement in a plant are few, the excuse for neglecting these few is less than if there were many; and the man in the plant which is in good shape is under obligation to himself to keep up with progress. He should also know what the other fellow is doing, that he may be able to tell whether he is doing as well with his plant as are others with their plants; if not, the most unprofitable use to which he can put his intellect is the invention of excuses for his failure, for failure is inexcusable.

If handicapped in his efforts by antiquated apparatus and slouchy perform-

ance of duty on the part of subordinates and assistants, an attempt to arouse a spirit of emulation in the engine- and boiler-room forces should be made, a series of tests and records inaugurated, and the results laid before the management in convincing testimony that investment in improvements and new apparatus will be in the path of wisdom. Constant study is necessary to meet the demands of modern requirements. The engineering paper which is full of new ideas and wrinkles, devices and resources and records of accomplishments, must be read from cover to cover, for there is information on every page—advertising, editorial, correspondence—and none can be neglected except at a direct loss. Meetings of engineers' associations, conventions and outings must not be neglected. Someone has truthfully said: "I am a part of all whom I have met;" and the engineer will certainly be a part of all whom he meets. To meet, to greet, to touch elbows and rub shoulders, to chat and discuss live questions with fellow engineers is to live with others in a higher and broader life than is his who, forgetting or not knowing of the benefits of emulation and coöperation, leads the solitary, one-sided life of the man who is sufficient unto himself.

Get Wise!

To the engineer who strives to keep in the front rank of his profession the report of the Massachusetts Gas and Electric Light Commission for 1907 will furnish much that is both pertinent and interesting, particularly along lines pertaining to the cost of generation and distribution of electric energy in central-station practice. Low cost of generation and distribution at the central station is a necessity and the possibility of cutting off a fraction of a cent of the cost per kilowatt-hour is an economy which will not be overlooked by the management. As would be expected for obvious reasons, the cost per kilowatt-hour at the switchboard is found lowest in the largest stations, 0.83 cent being the average figure reached by the Boston Edison Company's plants. This cost includes every item pertaining to the station expense, fuel, water, wages, rentals, depreciation, repairs, tools and appliances.

A particularly interesting feature of the report is the item of station cost per kilowatt-hour at Lowell, which was nearly as low as that at Boston, being 0.98 cent, while the cost of coal was sixty per cent. higher and the kilowatt output per pound of fuel ten per cent. less than at the Boston stations. The Boston stations consist of a modern equipment of engines and turbines, with mechanical facilities for handling and storing large quantities of coal, and were designed for the economical production of current on a large scale, while at Lowell the plant was not what could be called a modern one, and has since been replaced by a complete turbine installation. The cost of energy per kilowatt-hour in other large stations ranged from 1.07 cents at Malden to 1.4 cents at Fall River, and the coal consumption from 2.65 pounds per kilowatt-hour at Boston to 4 pounds at Fall River. The total cost of current, including distribution to consumers, ranged from 2.82 cents per kilowatt-hour at Lynn to 4.7 cents at Fall River.

In a State so largely devoted to manufacturing as is Massachusetts, the extension of motor service will be expected, and it is of considerable interest to the operating engineer of the smaller plant to know to what degree the extension of motor service will affect him. Is his plant in such condition that he can meet the competition of the central station, which was designed and built for the express purpose of putting him out of business, by furnishing the same product on terms more favorable to the power user? If his plant is not in condition to meet this competition, can he place the case in all its phases before the owner in clear and concise terms that cannot be misunderstood and by this secure the latter's coöperation in his efforts to raise the standard of his plant to a higher efficiency? The tendency is for the present toward concentration and where this concentration promises to result in economies in production, or in more reliable and convenient service, it will be adopted. Can the engineer analyze these promises intelligently and logically, and show whether they may be fulfilled?

Numbers of plants have been closed and the operating force largely turned adrift where an intelligent investigation of the circumstances, followed by slight changes and improvements along the lines of modern practice, would have resulted in the retention of the force and the production of power at a price that the central station would not meet. There is no factor that enters into the cost of power production that the engineer should not have at his fingers' end, ready for instant use, and the engineer who is not so equipped is not treating himself right. Every man owes it to himself to make the most out of life that he can and, to do this, advantage must be taken of every trifle. The engineer who knows and who knows why he knows, and can show why he knows, is the engineer who is consulted when changes and new installations are contemplated. He it is who knows whether the central-station promises of reliable and continual service at a cheaper rate can be fulfilled, and he can demonstrate the desirability of the isolated plant as compared with the service of the central station, if such desirability exists. It is up to the engineer to get wise to the possibilities of his own plant in order to be able to meet the competition from the central station, for meet it he must. Whether he meets it successfully will depend largely, of course, upon the plant with which he is connected, but it will likewise depend in a great measure upon himself.

Engineers' Examination Questions

Engineers' examinations and the method of conducting them are of interest to a large number of engineers and the attention that is being given to the subject is on the increase. In some instances in the examination of engineers by inspectors the use of textbooks is allowed and a higher percentage of accuracy required than where the textbooks are not used. A list of questions which is compiled from several sets of questions sent in from Ohio, Michigan, Massachusetts, and other places, and which contains only practical questions, is published elsewhere in this issue; the correct answers to which will be published in a future issue. To those who wish to reply to these questions through the columns of the paper, a welcome is extended.

The greatest benefit to be derived from these questions and their solution will come to those who exercise their talents in this direction, rather than to those who, however much desiring to know the correct answers, wait with much or little patience for the appearance of the answers. Mental exercise gives the same benefit to the mind that calisthenics does to the body. If an athlete confined his training to watching in an interested way the performance of feats of strength and agility by others, attempting the performance of none himself, he would be far from the winner of a first prize at a tournament. It would be the same with the engineer who is content to have problems and examination questions solved by others. He derives no good from the solutions so obtained, even though he remembers the solutions, which is doubtful. Mental food, like physical food, must be assimilated to be of any value.

It is expected that many sets of answers will be received to the questions and those which are considered the best will be published, instead of the answers which would otherwise be furnished by the regular puzzle editor. In the cases where the use of reference books and textbooks is indulged in it is not held that this use will in any way cheapen the work of the student. The manner in which the book is used decides this. The engineer who uses textbooks to any extent will refer to the published tables and other matter intelligently and quickly, while the man who is not accustomed to this class of work will get into deep water before he knows it, and flounder helplessly, deriving little or no benefit from the means of aid that he does not know how to use.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The Massillon Feed Water Heater

The Massillon feed-water heater, purifier and oil extractor, manufactured by the Russell Engine Company, Massillon, O., is illustrated and described herewith.

The upper part of shell is built of steel, the head and lower part being of cast-iron. The shell is connected to the head and bottom by means of cap screws so that it may be taken apart should it be

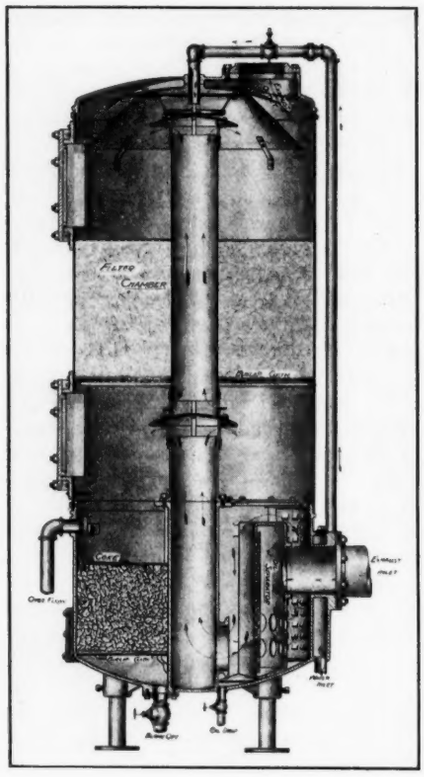


FIG. 1. SECTIONAL VIEW OF MASSILLON HEATER

necessary. The heater rests on pipe legs which enter sockets on the cast-iron base having set-screws to hold them rigid.

The water on entering the heater is delivered on top of the spraying cone over the top of the internal exhaust pipe shown in Fig. 1, where it is broken up into small particles as it passes through the steam to the filter beds. The filter beds are composed of excelsior, consisting of one or more according to size of heater, which rests on perforated plates covered with from three to five layers of burlap. The perforated plates are placed on top of the excelsior to hold it in position. These beds are from 20 inches to 4 feet in thickness according to the size of the heater. The arrangement is shown in the filter chamber.

The filter is provided with a skimmer which is a circular section, of trough shape, and covered on top to prevent water from splashing into it. It is screwed onto the end of the overflow pipe. A coke filter is located at or near the bottom of the lower cast-iron chamber which rests on a perforated steel plate through which all the water passes in entering the openings at the bottom of the water pockets, from which the water flows to the pump, to allow heavy particles to remain at the bottom.

An oil separator is located in the lower cast-iron part of the heater, and the oil is separated by dashing the steam against the interior wall of the exhaust box which is ribbed to catch the oil. From there it is dashed through holes in the front side of the exhaust box against a galvanized-iron plate with tongues protruding downward which conducts the oil and steam against the cooled wall of the extractor chamber after which it passes up and over the exhaust box to a cavity leading to the outlet, the walls of the cavity acting as an oil separator.

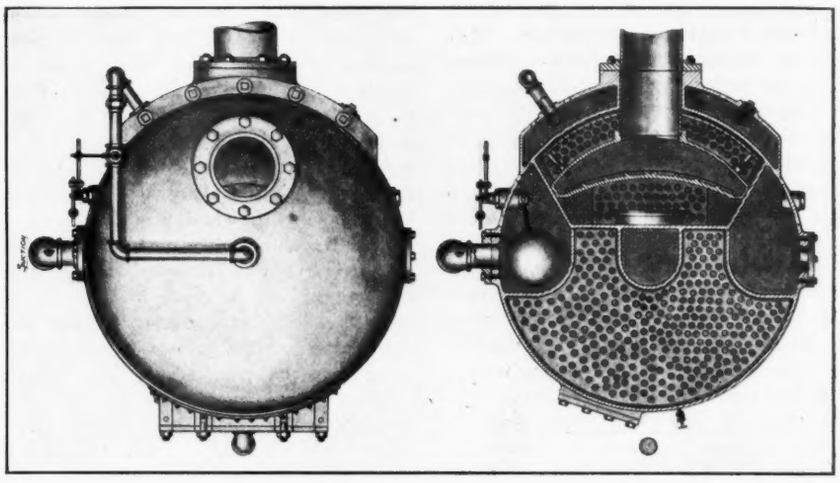
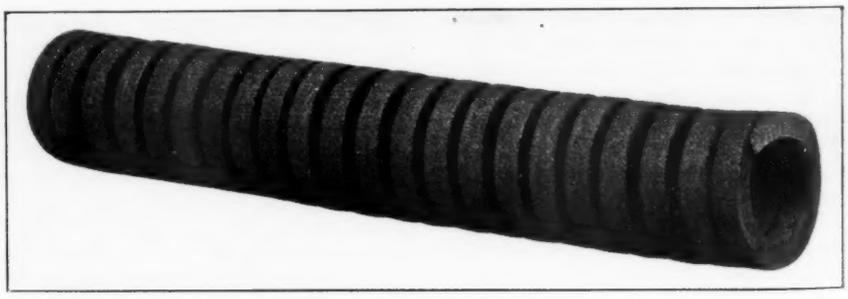


FIG. 2. OUTSIDE END AND SECTIONAL VIEWS OF THE HEATER

The feed water enters at the bottom of the water jacket and, circulating through it, is conducted to the top of the heater through a pipe having a balanced value controlled by a float connected to it and thus regulating the amount of water required automatically. This is shown in Figs. 1 and 2.

"Hot Stuff" Hydraulic Packing

"Hot Stuff" hydraulic packing is first made, then coiled and lastly vulcanized. It is ready for use as soon as received, and does not require steaming or soaking in hot water in order to make it ductile. There is no rubber used in its construc-

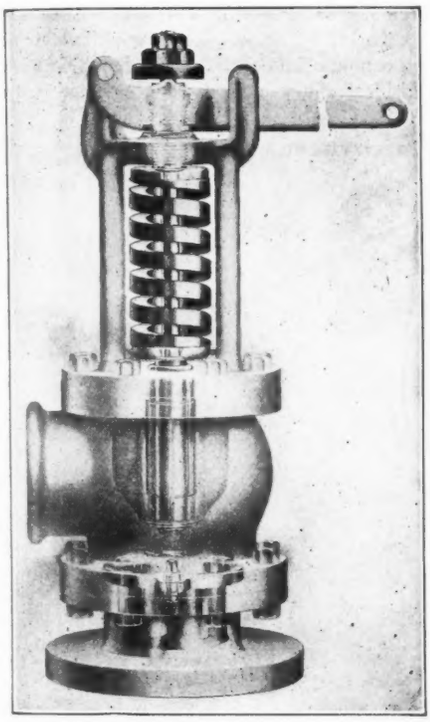


"HOT STUFF" HYDRAULIC PACKING

tion. The packing is treated with a special lubricant which consists largely of plumbago. This packing is manufactured by the "Hot Stuff" Packing Company, 50 Church street, New York City.

"American" Outside Spring Pop Safety Valve

With the rapidly increasing use of superheated steam it has become necessary to produce a spring-loaded pop safety valve of a type suitable for the high temperature of superheated steam.



"AMERICAN" OUTSIDE SPRING POP SAFETY VALVE

To meet this demand, the American Steam Gauge and Valve Manufacturing Company, 220 Camden street, Boston, Mass., has designed a type of valve having an outside spring and constructed of metals.

The entire body and outer casing of the valve are made of steel. The seat bushing which guides the valve proper is made from a solid nickel casting and the valve proper is made from one solid nickel casting. The valve top or open-spring casing is extended into the main body of the valve and is fitted with a solid nickel bushing which is recessed and acts as a suitable guide for the spindle.

The spindle is fitted with a loose-flange or spring seat having a spherical bearing, which together with the follower or top plate which guides the spring at the top, which is also fitted with a spherical bearing, distribute the load on the spring under compression.

The spring is made of high-grade steel and is proportioned to give the valve the greatest possible efficiency. The "American" adjustable blow-down ring is used as a means of adjusting the closing point of the valve. The lifting levers may be either of the straight horizontal type or of the compound-link drop-lever type, so proportioned as to permit the lifting of the valve from its seat one-eighth of its diameter.

Lagonda Reseating Machine

The essential part of the Lagonda reseating machine consists of a flat emery stone mounted upon a steel disk, Fig. 1, and rotated at high speed. The emery stone which is applied to the faces to be cleaned may be quickly replaced by emery cloth or sandpaper of any grade of coarseness. A removable, steel guide ring is fastened to the flat or front surface of the wheel to center it within the header opening or cap. The disk is flexible on its shaft so that it seats itself against all of the surface being cleaned. The shaft is operated by a turbine water wheel, Fig. 2, similar to that in a boiler-tube cleaner or by a small dustproof electric motor, equipped with two handles, Fig. 1, for pressing the wheel against the work.

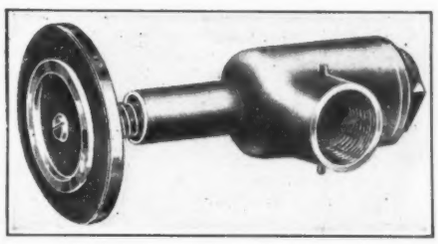
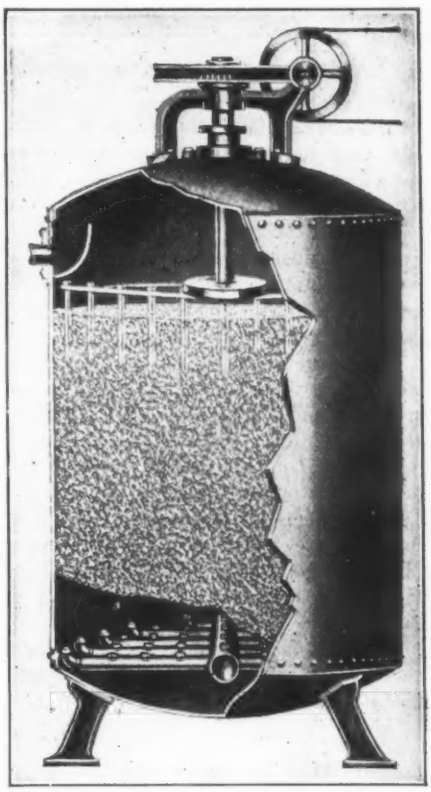


FIG. 2. WATER-DRIVEN RESEATER, SHOWING EMERY-CLOTH FACE AND GUIDE RING

In cleaning the header faces, the operator passes from opening to opening, a mere touch against each being sufficient. The caps and nuts are cleaned by applying their faces to the emery stone while the machine is securely fixed in one position. One operator in this way, it is said, can easily clean all the caps, nuts and faces of a 108-tube Babcock & Wilcox boiler in less than an hour. The cleaner is manufactured by the Lagonda Manufacturing Company, Springfield, O.

The Keystone Pressure Filter

The filter which is shown in the illustration is simple in construction and operation. It consists of a cylindrical steel shell standing upright on cast-iron legs



KEYSTONE PRESSURE FILTER

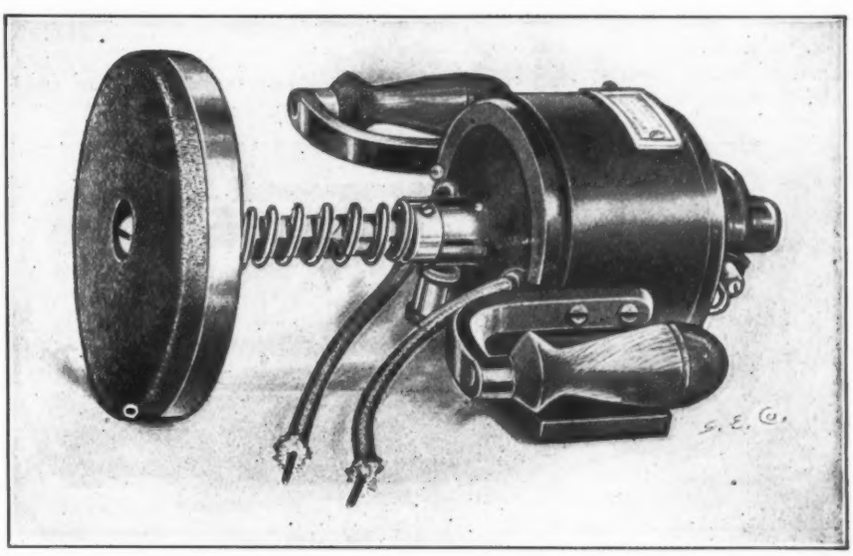


FIG. 1. LAGONDA RESEATING MACHINE, MOTOR-DRIVEN, WITH EMERY-STONE FACE

and contains a deep bed of crushed and sifted quartz. The seams are double-riveted, for it must resist more than boiler pressure, being located between the feed-pump and boilers. At the top is a steel agitator operated by a worm gear, by which the filtering bed may be thoroughly broken up when desired. In the bottom of the bed of quartz is a system of strainers, arranged to insure a uniform draft on all parts of the bed so that the work of filtration shall be evenly distributed throughout the bed of quartz.

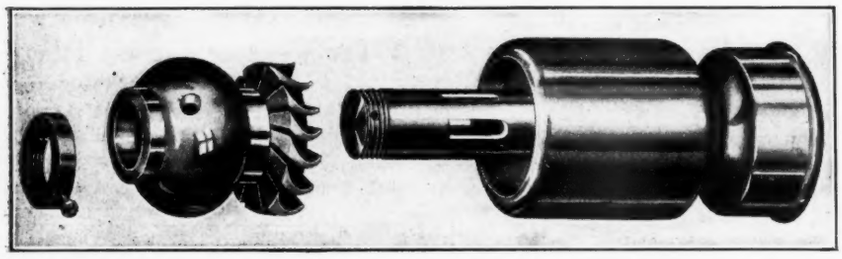


FIG. 1. "PERFECTION" CLEANER PARTS

The strainers themselves are of non-corrosive bronze, and the top being solid, enables the weight above to be easily supported.

The openings for receiving the filtered water are vertical in the sides of the strainers, and of ample total area to allow free flow of water to the outlet pipes, which unite in one central drain which delivers the purified water to the boiler.

Special pipe connections, not shown in the cut, are provided for washing the filter, by which the sediment, foreign matter, etc., can be removed and carried to the sewer.

The filter is manufactured by the Keystone Chemical Manufacturing Company, Philadelphia, Penn.

Perfection Tube Cleaner

A device for washing the tubes of a water-tube boiler, known as the "Perfection" tube washer, is manufactured by Earle C. Perry, Merchants-Laclede building, St. Louis, Mo.

The "Perfection" tube washer is operated on the water-turbine principle, which rotates the head at about 800 revolutions per minute. The water is thrown on an angle out of the head from two openings, and as the hose is passed down through each tube for its entire length the loose matter is driven before it. Fig. 1 shows the parts of the cleaner; Fig. 2 shows the cleaner assembled.

It is claimed that this device will remove a surprising amount of sediment and loose scale, even after the same tubes have been washed out with a straight nozzle. The washer has a 1¼-inch standard hose connection and requires 30 pounds water pressure to drive it.

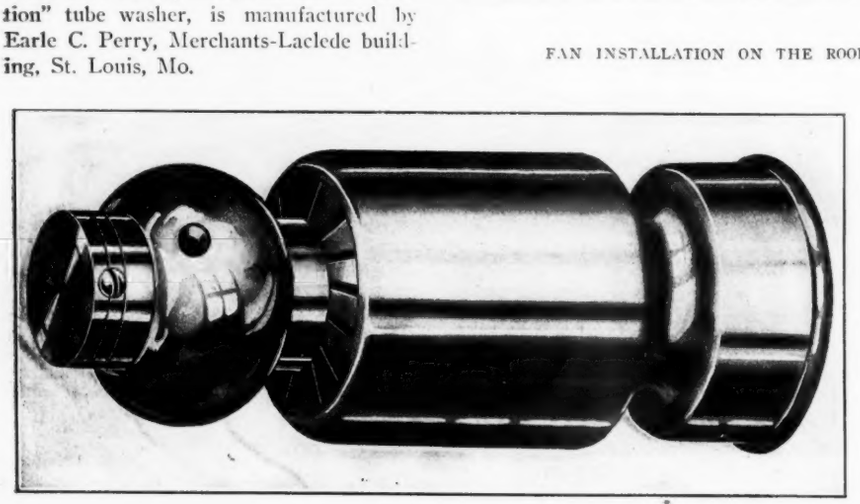
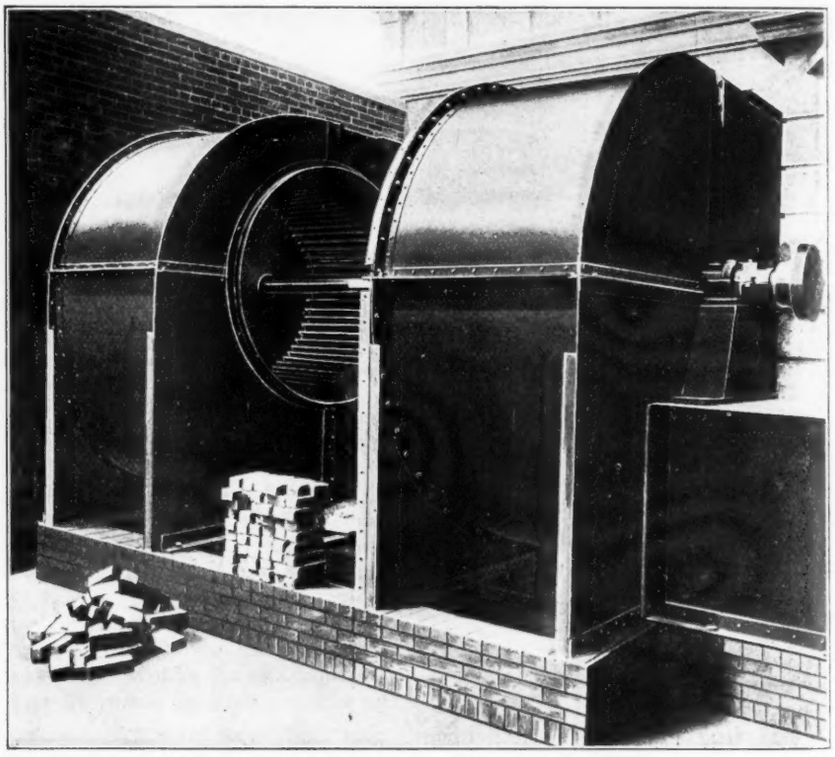


FIG. 2. THE CLEANER ASSEMBLED

Interesting Fan Installation

There has just been completed on the roof the Hotel Astor, New York City, a fan installation which consists of two 66-inch single-inlet Sirocco fans running on the same shaft. This shaft is 14 feet between bearings. The fans draw from a common intake chamber 5 feet 8½ inches wide. They are direct-connected to a 35-horse-power motor. The capacity of the fans is 50,000 cubic feet of air per minute each, against a ¾-inch water gage. The flue through which the fans exhaust is of brick. The photograph showing the principal features of the installation was made prior to the bricking-up of the central intake.



FAN INSTALLATION ON THE ROOF OF THE HOTEL ASTOR, NEW YORK

George R. Estabrook, secretary and manager of the Fisher Governor Company, died August 20 at his home in Marshalltown, Iowa, in the forty-ninth year of his age. Mr. Estabrook relinquished active duties some time ago, owing to ill health, and up to the time of his death had only acted in an advisory manner in the company's affairs.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Water in the Dry Vacuum Pump

Is water used in the dry-vacuum pump of a steam-turbine condensing system?

C. S.

Water is not used in the dry-vacuum pump of a steam-turbine condensing engine except by accident, and then there is trouble. These pumps are made with the least possible clearance, and a separator is usually provided to insure that no water shall be carried over into them.

Combustion

Give a short definition of the word "combustion," as used by the license examiner.

C. S.

Combustion, in the ordinary sense, is the rapid oxidation of matter, usually carbon or hydrogen, which is oxidizable (combustible). One atom of carbon appropriates two atoms of oxygen from the atmosphere forming carbonic-acid gas (CO_2). Two atoms of hydrogen appropriate one atom of oxygen forming water (H_2O). Slow oxidation, such as the rusting of iron, or the decay of a log, is the same process, chemically, and the gradual rotting away of a log in the woods produces as many units of heat as though the log was burned in a furnace; but it is only when the oxidation is so rapid as to produce the heat so much faster than it can be dissipated that a considerable elevation of temperature, and usually the formation of flame, is accomplished that combustion is popularly recognized as having occurred.

Valve Opening, Boiler Seams and Compression

(1) When a Putnam engine is placed on the center, how much opening should the exhaust valve have?

(2) Are return-tubular boilers made with double-riveted girth seams?

(3) When setting the valves on a slow-speed engine, how far from the end of the stroke should the piston be when the exhaust valve begins to open? I am speaking of four-valve engines.

(4) If the clearance is the same in both engines, and compression begins 3 inches from the end of the stroke, one engine having a 10-inch cylinder and the other a 20-inch cylinder, both exhausting to atmosphere, will not the compression be the same in both engines?

L .F.

(1) Three-sixteenths of an inch.

(2) As far as known, the curvilinear seams on all boilers are single-riveted.

(3) About one-eighth of the stroke.

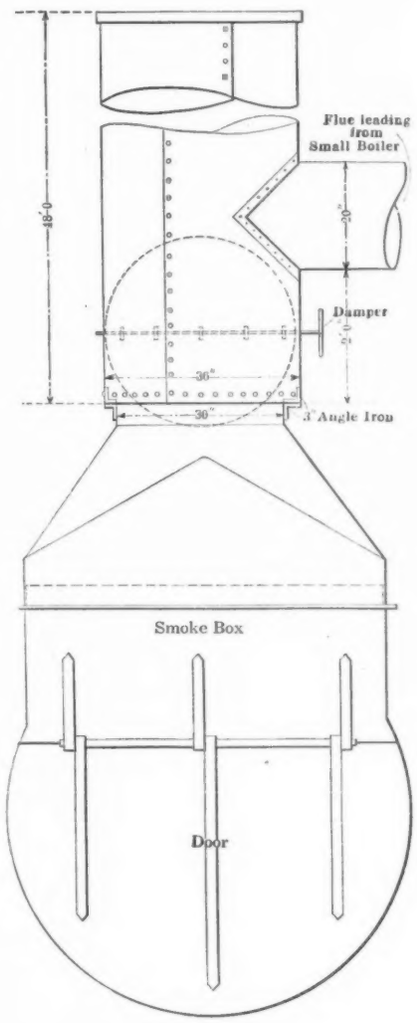
(4) If the per cent. of clearance were the same in both cylinders the compression would be the same.

Stack Diameter and Hight

Accompanying is a sketch of a smoke-stack, 36 inches in diameter and 48 feet high, which replaced one 58 feet high and 30 inches in diameter. Since the new stack has been used the boiler does not seem to steam as well as with the old stack. When the new one was erected the hole in the smoke box was not enlarged, but a 3-inch angle iron was placed inside at the bottom to make contact with the 3-inch angle iron on the collar on the smoke box. Were matters bettered any?

H. T.

The larger stack would have a greater capacity, as far as grate surface is concerned, than the smaller one, but the intensity of the draft would be much less. From several complex formulas and the observed results of successful practice, a simple rule for chimney design has been deduced which is used by many engineers. It is this: The area of the chimney should be one-eighth of the area of the grate and 25 times its diameter in hight. The intensity of the draft of a chimney depends upon the difference in weight between the column of hot gases inside the chimney and the weight of the cooler air outside. With the gases at a temperature of 600 degrees, and the temperature of the outside air at 60 degrees, the intensity of the draft in inches of water can be approximately calculated by multiplying the hight of the stack above the grate by 0.0073. In this case, assuming that the base of the stack was 10 feet above the grate, the hight of the 36-inch stack would be 58 feet and the draft measured in inches of water should be 0.421; the top of the 30-inch stack would be 68 feet above the grate and the draft would be, by the same rule, 0.496, quite a noticeable difference. The grate areas of your boilers are not given, but it appears highly probable that a 30-inch stack 68 feet above the grate would take care of both boilers and give better satisfaction than a 36-inch stack 58 feet above the grate.



SKETCH OF STACK

Pumping over the Top or in the Bottom of Tank

We have a tank, 8 feet high, located on a 70-foot tower. Will it make any difference whether we pump in at the bottom or over the top?

J. Z

If the tank is kept full of water all the time it will make no difference whether the water enters at the bottom or at the top. But if the tank is to be emptied, or kept only partially filled, there would be a gain by pumping in through the bottom equal to the difference between the top of the water and the point where the pipe enters the top of the tank. The difference in pressure to be pumped against would be equal to 0.433 pound for each foot in hight.

Why Does Not the Safety Valve Close?

Our boiler is equipped with a Crosby pop safety valve. It opens all right, but does not seem to close. What is the matter with it?

A. S.

The Crosby pop safety valve is provided with a screw ring, on the outside of the seat, which is employed to regulate the action of the valve by permitting more or less steam to escape through the holes in the flange. Raising the ring causes the valve to blow longer, while lowering it shortens the time of blowing and hastens the closure of the valve. The ring is reached by removing a tap bolt in the valve casing opposite the discharge opening, and the ring may be turned up or down by means of a screwdriver until the steam escape is as desired. All pop safety valves are provided with some device which accomplishes the same result.

R. M. Neilson, author of "The Steam Turbine," is severing his connection with Richardsons, Westgarth & Co., Ltd., to open an office as consulting engineer and patent agent. Mr. Neilson at present occupies the post of chief of the technical department at Messrs. Richardsons' Hartlepool (England) works.

Combined Coal and Gas Firing

Demonstrations have recently been given in London to show the practical application of the combined use of liquid and solid fuel in the furnace of a steam boiler, the company which is introducing the process being the Direct-Gas Fuel, Limited. The essential feature of this process is that the oil is gasified in retorts which are arranged in the furnace. The oil is first injected into the retort from the front of the furnace by a jet of steam through a special burner, and from there it travels through the center of the furnace to the end of the fire, then along the back of the fire, and returns to the front, being all the time within the heated retort. On reaching the front of the furnace in a gasified state, it is blown down on the top of the fire, where it burns with an intensely hot flame.

The proportion of oil and coal can be varied at will, and it is claimed that with the addition of 3 per cent. of oil bituminous coal can be burned without smoke, the efficiency being very high. It is stated that tests which have been carried out showed a high evaporation per pound of inferior coal, the solid fuel being aided by about 12 per cent. of oil during the trial. This is claimed to be one of the advantages of the system, for a cheap inferior coal, having an evaporative power of about 6 pounds of water per pound of coal, will, when burned with the proportion of liquid fuel stated, give an evaporation of about 10 pounds of water per pound of coal. Another advantage put forward is that with this system sudden calls for increased steam can be responded to with promptitude. Smoke can also be almost entirely prevented.

The College of Engineering of the University of Illinois is making great strides, so that not only has it been found necessary to appoint an assistant to Dean W. F. M. Goss, but thirteen additional assistant professors and instructors have been appointed for the college year beginning September 16. The new assistant dean is F. D. Crawshaw, graduate of the Worcester Polytechnic Institute, class of '96, who has served as head of the manual-training department of the Central high school at Minneapolis, as first assistant in the manual-art department of the Bradley Polytechnic Institute and as principal of the Franklin school at Peoria, Ill.

Columbia University will offer twenty evening courses especially adapted to the needs of technical and professional workers. These include work in applied mechanics, applied physics, architecture, electricity, fine arts, industrial chemistry, mathematics and surveying and structures. The work will begin on October 26 and will continue for twenty-five weeks. A full description of the courses is contained in the "announcement of extension teaching," which may be obtained on application to the director of extension teaching, Columbia University, New York City.

Business Items

The Industrial Power Company, of Milwaukee, Wis., has changed its offices from the Iron building to 621 and 622 Caswell block.

Announcement is made that C. P. Wood, of Atlanta, Ga., has established an office, as manufacturers' agent for power-plant and mill equipment, at 1028 Candler building.

The York Manufacturing Company, York, Penn., manufacturer of ice-making and refrigerating machinery, reports thirteen recent sales aggregating 262¼ tons of refrigeration.

The Harrison Safety Boiler Works, Seventeenth and Clearfield streets, Philadelphia, has just issued a booklet containing "A Few Coal Facts" and treating especially of the various uses to which Cochrane heaters may be put.

We have been advised that the "Tauril" sheet packing can now be purchased only from the Anchor Packing Company, of Philadelphia, Penn., its branches, or authorized agents. The Anchor company has the sole sales agency for the United States.

The Minneapolis Sewer Pipe Works recently awarded the contract for the power equipment for its new plant at Hopkins, Minn., to the Minneapolis Steel and Machinery Company. The contract includes a 20x48-inch heavy-duty Twin City Corliss engine, feed-water heater, pumps, etc.

A new office has been opened in the Gumbel building, Kansas City, Mo., by the Crocker-Wheeler Company, Ampere, N. J., for the sale of C-W motors, dynamos, transformers, switchboards, etc. The office is in charge of A. W. Paine, who will give personal attention to business in Kansas City and vicinity.

The Cadick Milling Company, of Grand View, Ind., uses Stirling boilers in its plant and used to have a lot of trouble with the boilers foaming. Buckeye boiler skimmers, made by the Buckeye Boiler Skimmer Company, South End, Toledo, O., were installed, and the management states that since then there has been no trouble and the company is very much pleased with them.

Two orders for the Koerting patent oil-firing system have lately been booked by the Schutte & Koerting Company, of Philadelphia, for equipping the new battleship "North Dakota," being built by the Fore River Shipbuilding Company, and the "Delaware," being built by the Newport News Shipbuilding Company. This system is in successful use in the English and German navies, the new English "Dreadnaught" class being equipped with it. Catalog 6-O, giving a full description of this system, can be obtained from the manufacturer.

In these times of short production and suspension it is pleasant to find the Vilter Manufacturing Company, of Milwaukee, Wis., running nights. From the first of April until July 20 they ran eight hours per day. At that time they returned to 10 hours, and on August 10 started a night gang. In the last four weeks they have put a hundred additional men to work. Their output consists largely of Corliss engines, refrigerating machinery and dry-blast apparatus, whereby the moisture and impurities are condensed out of air before it is used in blast furnaces, steel converters, etc.

The Hall & Woods Company, flour miller at Lima, Ohio, states, in regard to the Buckeye boiler skimmer in use in its plant, that a trifle over a gallon of heavy solid mud is drawn from the drum every day. This is very plain evidence as to what the skimmer is doing, for, if this much scale-forming sediment is removed before it has little chance to settle, the value of the skimmer is apparent. It is also found that the scale that was in the boiler before the skimmer was attached is being loosened. Previous to the installation of the skimmer they were compelled to clean the boiler every week, but now once in every two weeks is sufficient, and their engineer thinks that after the skimmer has removed all of the old scale they will be able to run a whole month without cleaning the boiler.

For the second time in three years the refining building, known as building No. 3, of the plant of the F. S. Walton Company, of Philadelphia, has been completely destroyed by fire, which occurred on the morning of August 15 and consumed twenty tanks containing about 10,000 gallons of pure neatsfoot oil. The total loss is estimated at between $25,000 and $30,000, partially covered by insurance. By the time this announcement appears a new building will be nearing completion, if not already finished, as workmen were started clearing away the debris as soon as the ruins were sufficiently cooled to permit operations, the building being one of great importance in the manufacture of the company's product. As the new structure will be an exact duplicate of the building burned, no new plans were necessary, it having been demonstrated that the arrangements of size, two stories, 75x30, and equipment, were as perfect as could possibly be secured. The F. S. Walton Company, being the largest distributor of neatsfoot oil in the world, is naturally a heavy exporter, its largest foreign warehouses being located at Havre, France, and Antwerp, Belgium. About two years ago this company placed on the market a new belt dressing, under the name of "OxoilOx," the base ingredient of which is pure neatsfoot oil, pressed and refined from the finest hoof stock obtainable. It has already reached a wide sale. Being made from the hoofs of cattle, while the belt is made from the hide, it is a natural product that, it is said, cannot harm the leather, and the manufacturer claims it puts back into the belt practically all the natural strength and vitality lost in tanning the rawhide. Judging from the number of testimonial letters received from prominent firms it is proving what is claimed for it.

New Equipment

A new boiler house is being erected at the mill of Crane Brothers, Westfield, Mass.

An addition to the power plant at the Newark, N. J., penitentiary, is being erected.

The Canton (N. Y.) Electric Light and Power Company will erect a new sub-station.

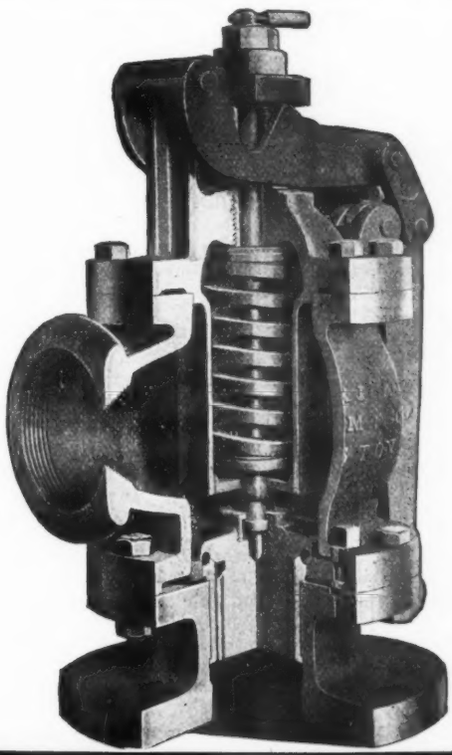
The Mayfield (Ky.) Water and Light Company will erect a power plant to cost $10,000.

It is stated that the Martin Hosiery Mill, Raleigh, N. C., will install electrical equipment.

The Athens (Ga.) Electric Railway Company will increase the output of its power plant.

The Ocala (Fla.) Manufacturing Company, expects to increase the capacity of its ice plant.

The Western Electric Company, Jamestown, N. D., contemplates installing two new boilers.



Which Shall it be?

The Genuine "American" or the Other Kind

¶ Will you entrust the safety of your plant to the valve that works "*perhaps*", or the valve that works *always*?

¶ The pre-eminence of the "American" can easily be explained. It's different. It's more reliable.

¶ Take the body for instance. We make it extra heavy of the finest steam metal. That's why it withstands high pressures.

¶ The "American" never sticks on the seat. It can't. It's automatic, prompt and positive.

¶ You know the effort *some* valves require. But not ours. The movement is vertical throughout. The lifting lever is very powerful.

¶ Some valves are inaccessible. Not so with the "American", the spring, spindle and valve proper can be instantly removed without disturbing the outlet connection.

¶ Another thing. A specially designed testing nut. There to enable you to test the boiler under water pressure without increasing the load on the spring.

¶ These are just a few of the distinctive features that make the "American" the World's best valve.

¶ It pays to insure your boilers against explosion. The longer you use the "American" the better you appreciate it. Circular 1-D?

American Steam Gauge & Valve Mfg. Co.,

208-220 Camden Street, Boston, Mass.

New York, 26 Cortlandt St. Atlanta, 835 Equitable Bldg. Chicago, 7-9 So. Jefferson St.

Pittsburg, Frick Bldg. Annex
Montreal, 444 St. James Street
San Francisco, 247 Pine Street
Los Angeles, 213 So. Angeles Street

The Parkersburg (W. Va.) Ice Company will rebuild its ice plant recently destroyed by fire at a loss of $125,000.

The Rangeley (Me.) Light and Power Company has under consideration the question of doubling its output.

The Seguin (Tex.) Electric Light and Power Company is preparing plans for rebuilding its water-power plant.

The City Council, Worthington, Minn., contemplates installing a new generator in the municipal electric-light plant.

The citizens of Price, Utah, are considering the question of establishing a municipal electric-light plant. Plans are being prepared.

The Williamsville (N. Y.) Electric Light and Power Company has been granted permission to construct and operate an electric plant.

The citizens of Sparta, Mich., voted to issue $20,000 bonds for the construction of an electric-light plant. E. G. Anderson, village clerk.

The Meldrum Chemical and Engineering Company, Zebulon, N. C., is said to be planning to install an electric-light plant and water works.

Plans are being considered by the Town Council, Richlands, Va., for the construction of an electric-light plant, water-works and sewer systems.

The Kansas City and Springfield Southern Railway Company will erect an electric-light plant at Arcola, Mo. C. C. McFann, Nevada, Mo., general manager.

The Shelbourne Falls (Mass.) Electric Light and Power Company will erect a new power house. A 125-horsepower gas-producer engine will be installed.

Plans are being considered for an addition to the municipal electric-light plant at Owensboro, Ky., and a 500-horse-power boiler will be installed. E. H. Breidenbach, manager.

The Durham Cotton Manufacturing Company, East Durham, N. C., is planning to install electrical equipment to operate its plant at a cost of about $50,000.

The new buildings for the West Point (Ga.) Manufacturing Company are nearly completed. The power plant will have a capacity of 3000 horsepower.

The Belleville & Reedsville Railway Company has been chartered with $100,000 capital stock to build an electric railway. M. L. Yoder, Belleville, Penn., president.

The Manchester (Ky.) Traction Company will build an electric railway connecting Barboursville, Ky., and Manchester. Louis des Cognets, Lexington, Ky., president.

Plans are being considered for the installation of a new engine, dynamo and switchboard in the municipal electric-light plant at Seneca, Kan. G. D. Myers, manager.

The Wausau (Wis.) Street Railway Company is having plans prepared by the Knox Engineering Company, of Chicago, Ill., for the construction of a power plant to cost over $80,060.

The Aberdeen (S. D.) Street Railway Company has been incorporated to construct an electric street railway. Capital, $250,000. Incorporators, Chas. T. McCoy, Frank H. Haggerty, Frank W. Brooks, etc.

New Catalogs

The Multiple Woven Hose and Rubber Company, Worcester, Mass. Booklet. Multiple woven waterproof belting. 6 pages, 3½x6 inches.

The Triumph Ice Machine Company, Cincinnati, Ohio. Bulletin No. 504. "Dog House" steam condenser. Illustrated, 16 pages, 6x9 inches.

Alberger Condenser Company, 95 Liberty street, New York. Catalog No. 9. Alberger condensing apparatus. Illustrated, 96 pages, 6x9 inches.

American Injector Company, Detroit, Mich. Catalog. U. S. automatic injectors, grease cups, oil cups, water gages, gage cocks, etc. Illustrated, 88 pages, 3½x6 inches.

Continental Iron Works, West and Calyer streets, Brooklyn, N. Y. Catalog. Morison suspension furnaces for internal-furnace boilers. Illustrated, 66 pages, 9x12 inches.

Rockwell Furnace Company, 26 Cortlandt street, New York. Catalog. Portable heaters. Illustrated, 8 pages, 9x12 inches. Catalog. Melting furnaces, 32 pages, 9x12 inches.

The Emerson Electric Manufacturing Company, St. Louis. Bulletin No. 3306. Electric blowers for furnaces. Illustrated, 8 pages, 7x10 inches. Bulletin No. 3134. Single-phase induction motors. Illustrated, 4 pages, 7x10 inches.

American Steam Pump Company, Battle Creek, Mich. Catalog No. 17. Marsh steam pump. Illustrated, 136 pages, 6½x7½ inches. Pamphlets. Power pumps and compressors and American simple and compound steam pumps. Illustrated.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

SALESMEN—I desire to correspond with some one visiting plants and handling engineers' supplies and appliances with a view of selling a device of merit. Box 37, POWER.

STEAM ENGINE ERECTING ENGINEER, capable of assisting in sales department, young man with shop experience and wide acquaintance among Eastern engineers preferred. Box 33, POWER.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

ASSISTANT ENGINEER, machinist by trade, wants position in large power or manufacturing plant. References. G. Werbeck, Woodbridge, N. J.

POSITION AS OILER, assistant electrician or rotary tender in New York City; experienced; can furnish good references. Frank O. Schneider, 414 Logan Ave., Waterloo, Iowa.

POSITION as superintendent or manager. Wide and successful experience in marine, mill, pumping engines, hydraulic and steam turbines and Corliss engine manufacture, installation and operation. Box 26, POWER.

CHIEF ENGINEER of large industrial plant desires change; active and alive, an expert with indicators and testing apparatus, can keep operating expenses at proper figures. Box 27, POWER.

ENGINEER, three years in present position, having charge of 2000 H.P. plant, desires a change. Capable of taking charge of a plant of this or larger size. Good reference. "L. M.," POWER.

POSITION by technical graduate, with four years' experience in steam turbines, gas engines, drafting, etc., as instructor in mechanical engineering with or without opportunity to do post graduate work. Box 35, POWER.

YOUNG CIVIL ENGINEER with energy and push desires position as traveling salesman with machinery and supply house; experienced in general construction work, in the design and manufacture of heavy machinery and structural steel; very best references and satisfactory reasons for making change. Box 38, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

ALL PRACTICAL ENGINEERS should apply to Wm. O. Webber, Consulting Engineer, 432 Exchange Bldg., Boston, for information concerning tables on all engineering subjects.

INVENTOR of a governor for any prime motor (most simple and sensitive design) wants money to further prosecute patent not having secured all basic claims the invention merits. G. & P., POWER.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-Examiner U. S. Patent Office, 4 Dietz Bldg., Washington, D. C.

GOOD FINANCIALLY SITUATED German sprinkler installation firm requires running deliveries of guaranteed first-class valves for wet and dry systems. Offers: F. K. 6648, Care Rudolf Mosse, Berlin, S. W. (Germany.)

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—One 66" new American turbine, with core wheel, bridge tree pinion and 4" shafting in good condition. Cheap. Address De Pere Electric Light and Power Co., De Pere, Wis.

FOR SALE—Two 60"x16' H. T. boilers; two 52"x16' H. T. boilers; one 8"x10", 125 R. P. M., Imperial engine, direct connected to 25 kw., 125 V., direct current Triumph generator; one 7"x8", 375 R. P. M., direct connected to 10 kw., 125 V., direct current generator; one 20 H.P. 500 V. Edison motor; one 7½ H.P., one 3 H.P., and one ½ H.P., 500 V., direct current General Electric motor. Address Thompson Hotel Company, Lincoln, Neb.

FOR IMMEDIATE SHIPMENT—New Hamilton Corliss engines: Three 18 and 36x42 tandem compound heavy duty, right and left hand, with direct-connected 380 kw. Westinghouse generators, exciters, etc.; 18 and —x42 heavy-duty cross-compound belted type engine; low-pressure cylinder can be furnished any size desired; 18x42 heavy duty, left hand and right hand; 16x42 girder frame, right hand; 12x36 girder frame, right hand; 14x30 girder frame, right hand; 14x36 girder frame, right hand; one Twin 26x48 heavy-duty engine; this engine can be separated and used singly if desired with new shaft and wheel. Second-hand Hamilton Corliss engines: 18 and 34x48 heavy-duty tandem-compound, right-hand, belted type; 10 and 18x30 heavy-duty tandem-compound, left-hand, belted type; 30x60 heavy duty, right hand; 12x30 girder frame, left hand; good as new; 24x42 heavy duty, left-hand engine, complete with direct-connected 300 kw. Westinghouse generator, exciter and transformers; one 96"x12" pulley, bore 8" in halves, weight 1100 pounds. Battery of two 60"x16 horizontal return tubular boilers with feed pump, feed water heater, stack, breeching, steam piping, etc., good condition. The Hooven, Owens, Rentschler Co., Hamilton, Ohio.

Alphabetical Index to Advertisers

	PAGE
Alberger Co., A. H.	103
Alberger Condenser Co.	104
Allan & Son, A.	109
American District Steam Co.	97
American Engine Co.	114
American Goetze-Gasket and Packing Co.	75
American Injector Co.	93
American School of Correspondence	67
American Steam Gauge and Valve Mfg. Co.	55
American Steam Pump Co.	102
Anchor Packing Co.	70
Anderson Co., V. D.	96
Armstrong Mfg. Co.	94

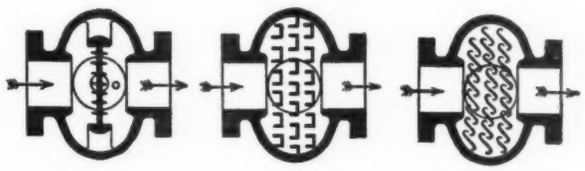
COCHRANE SEPARATORS

SINGLE vs. MULTIPLE BAFFLE

Now, when you wish to separate particles of water or oil from a current of steam, which type of Separator do you want? The Cochrane Separator is of the solid-baffle type; the flying particles strike against the baffle; they cannot bound back and they cannot be pushed sideways in the direction of the current of steam because the ribs prevent; then these particles of water or oil flow directly into the well, which the steam current does not enter.

Steam separators which use screens or many small baffles, or grids placed one behind the other really confess their own shortcomings in their construction, since if one or even two sets of baffles were effective in taking out the water and oil particles, why would you want more? It must be then that some particles get by the first row and more still by the second row of these multiple baffles, and that no matter how many rows are put in you still have only failure, as a certain percentage always gets by.

To stop a hail of bird shot, what would be most effective, a gravel screen, a picket fence, several picket fences one behind the other, or the side of a barn? We have proved that one baffle, of the right kind and properly placed, will take the water and oil particles out of the steam, so why compel the steam to work its way through long, tortuous passages, or a multiple of intercepting baffles, all of which only add resistance,—which means reduced live steam pressure,—or in the case of oil separators, additional back pressure ?



Observe another point, the ability of the baffle to clean itself. If there is one baffle for all the water and oil, the oil will be washed down continually into a well by the water. With a multitude of baffles, on the other hand, perhaps not enough water will strike the second and third rows to wash down the oil, and such separators, therefore, must be so arranged that the baffle plates can be taken out from time to time for cleaning, something that is never required with the Cochrane Separator.

However, regardless of the design or the principles involved, the Cochrane Separator does the kind of work you want, has done it in thousands of cases. Buy a Cochrane Separator and take no chances. The illustrations in our Catalogue No. 15-S, sent upon request, will show just the form required for your particular case.

HARRISON SAFETY BOILER WORKS,
17TH. & CLEARFIELD STS., PHILADELPHIA, PA.

TALK 5

	PAGE
Ashton Valve Co.	92
Babcock & Wilcox Co.	105
Ball-Cooley Engineering Co.	109
Ball Engine Co.	109
Baragwanath & Son, Wm.	102
Barnes Co., W. F. & Jno.	61
Bartlett & Snow Co., C. O.	97
Bates Machine Co.	100 and 111
Beggs & Co., Jas.	94
Berry Engineering Co.	107
Bignall & Keeler Mfg. Co.	92
Bird-Archer Co.	80
Borden Co.	93
Brandt, Randolph	77
Bristol Co.	116
Broomell, Schmidt & Steacy Co.	110
Brown Engine Co., C. H.	111
Buckeye Boiler Skimmer Co.	89
Buckeye Engine Co.	112
Burt Mfg. Co.	10
Cancos Mfg. Co.	76
Canfield Mfg. Co.	75
Carey Co., Philip	77
Central Station Steam Co.	102
Chaplin-Fulton Mfg. Co.	107
Clark Bros. Co.	112
Climax Smoke Preventer Co.	97
Cling-Surface Co.	63
Continental Iron Works	106
Cook's Sons, Adam	84
Cooper Co., C. & G.	113
C-O-Two Furnace Co.	97
Crocker-Wheeler Co.	107
Crosby Steam Gage & Valve Co.	61
Curtis & Curtis Co.	92
Davis Regulator Co., G. M.	90
Dean Bros. Steam Pump Wks.	105
Dearborn Drug & Chemical Works	5
De Laval Steam Turbine Co.	111
De La Vergne Machine Co.	109
Deming Co.	104
d'Este Co., Julian	96
Detroit Leather Specialty Co.	61
Detroit Lubricator Co.	84
Diamond Rubber Co.	74
Direct Separator Co.	94
Dixon Crucible Co., Jos.	85
Du Bois Iron Works	103
Eclipse Feed Water Heater & Purifier Co.	103
Edge Moor Iron Co.	106
Erie Mfg. and Supply Co.	112
Eureka Packing Co.	73
Fisher Governor Co.	107
Fitchburg Steam Engine Co.	113
Foos Gas Engine Co.	110
Fort Wayne Electric Wks. Co.	108
Foster Engineering Co.	88
Franklin Boiler Works Co.	106
Gardner Governor and Separator Co.	80
Garlock Packing Co.	9
General Electric Co.	114
General Specialty Co.	83
Goubert Mfg. Co.	94
Goulds Mfg. Co.	104
Green Engineering Co.	97
Green Fuel Economizer Co.	101
Greene, Tweed & Co.	86 and 116
Griffith & Wedge Co.	109
Griscom-Spencer Co.	101
Hammel Oil Burner Co.	97
Harrisburg Pipe and Pipe Bending Co.	100
Harrison Safety Boiler Wks.	57
Hawk-Eye Compound Co.	61
Heine Safety Boiler Co.	105
Hershey Machine and Foundry Co.	94
Hill Publishing Co.	63, 65 and 78
Hoffman, Geo. W.	109
Homestead Valve Mfg. Co.	87
Hoppes Mfg. Co.	99
Houchin-Aiken Co.	77
Huyette Co., Paul B.	93
International Correspondence Schools	87
Jeffrey Mfg. Co.	97
Jenkins Bros.	72
Johns-Manville Co., H. W.	79
Johnson Co., Henry	74
Keeler Co., E.	104
Kewanee Boiler Co.	106
Keystone Lubricating Co.	3 and 115
Kitts Mfg. Co.	95
Lagonda Mfg. Co.	82
Lammert & Mann	107
Leavitt Machine Co.	93
Liberty Mfg. Co.	81
Lippincott Steam Specialty & Supply Co.	61
Loew Mfg. Co.	101
Lunkenheimer Co.	89
Mabbs Hydraulic Packing Co.	77
McClave-Brooks Co.	7
McCrea & Co., James	92
McGowan Co., Jno. H.	105
McLeod & Henry Co.	98
Martin Grate Co.	97
Mason Regulator Co.	92
Mayville Specialty Mfg. Co.	97
Mercer Rubber Co.	76
Minneapolis Steel & Machinery Co.	1
Monarch Steam Blower Co.,	77 and 80
Morehead Mfg. Co.	94
Morrin Climax Boiler Co.	105
Mound Tool and Scraper Co.	109
Murphy Iron Works	97
Myers & Bro., F. E.	103
Nason Mfg. Co.	95
National India Rubber Co.	77
National Pipe Bending Co.	100
National Tube Co.	92
Neemes Bros.	96
New York Belting and Packing Co., Ltd.	71
Northern Electrical Mfg. Co.	109
Ohio Blower Co.	80
Ohio Brass Co.	93
Ohio Injector Co.	83
Oil Well Supply Co.	104
Oster Mfg. Co.	61
Parker Boiler Co.	106
Patterson & Co., Frank L.	101
Peerless Rubber Mfg. Co.	69
Penberthy Injector Co.	8
Pennsylvania Flexible Metallic Tubing Co.	68
Philadelphia Lubricator and Mfg. Co.	84
Phœnix Iron Works	113
Phosphor Bronze Smelting Co., Ltd.	97
Pierce Co., Wm. B.	2
Pittsburgh Gage & Supply Co.	85
Pittsburgh Valve and Fittings Co.	88
Pittsburgh Valve, Foundry and Construction Co.	90
Platt & Co., Jno.	96
Power Specialty Co.	106
Presbrey Fire Brick Works	98
Providence Engr. Works	109
Quaker City Rubber Co.	4
Randle Machinery Co.	110
Reeves Engine and Machine Co.	109
Reliance Gauge Column Co.	96
Restein Co., Clement	67
Rhoads & Son, J. E.	87
Ridgway Dynamo and Engine Co.	111
Riverside Engine Co.	110
Robb-Mumford Boiler Co.	105
Robertson & Sons, Jas. L.	73
Robins New Conveyor Co.	61
Rust Boiler Co.	106
St. John, G. C.	61
Saginaw Mfg. Co.	86
Sargent Steam Meter Co.	109
Schutte & Koerting Co.	91
Shepherd Engineering Co.	109
Shultz Belting Co.	86
Simplex Engineering Co.	92
Sirocco Engineering Co.	97
Skinner Engine Co.	112
Smooth-On Mfg. Co.	4
Southwark Foundry and Machine Co.	110
Starrett Co., L. S.	116
Steel Mill Packing Co.	76
Stephenson Mfg. Co.	87
Stewart Heater Co.	98
Strong, Carlisle & Hammond Co.	95
Struthers-Wells Co.	110
Sturtevant Co., B. F.	97
Toledo Pipe Threading Machine Co.	92
Trill Indicator Co.	86
Trimont Mfg. Co.	85
Triumph Electric Co.	108
Triumph Ice Machine Co.	107
Underwood & Co., H. B.	111
U. S. Mineral Wool Co.	77
Vanda Co.	75
Vilter Mfg. Co.	109
Vogt Machine Co., Henry	106
Walch & Wyeth	94
Walton Co., F. S.	86
Warren Steam Pump Co.	103
Watertown Engine Co.	109
Watson & McDaniel Co.	95
Watson-Stillman Co.	68
Webster & Co., Warren	59
Westinghouse Electric & Mfg. Co.	108
Wetherill & Co., Robert	113
Wheeler Condenser & Eng. Co.	103
Whitlock Coil Pipe Co.	100
Wickes Boiler Co.	105
Wiederholdt Construction Co.	97
Wilkinson Mfg. Co.	98
Williams & Co., J. H.	68
Williams Foundry and Machine Co.	87
Williams Valve Co., D. T.	88
Wing Mfg. Co., L. J.	97
Worthington, Henry R.	102
Yale & Towne Mfg. Co.	68
York Mfg. Co.	107

Classified Index to Articles Advertised

Air Compressors

American Steam Pump Co., Battle Creek, Mich.
McGowan Co., John H., Cincinnati, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Riverside Engine Co., Oil City, Pa.
Westinghouse Traction Brake Co., Pittsburg, Pa.
York Mfg. Co., York, Pa.

Air Cooling Apparatus

De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, Ohio.

Alarms, High and Low Water

Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Reliance Gauge Column Co., Cleveland, O.

Ammonia Fittings

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, O.
York Mfg. Co., York, Pa.

Ammonia Valves

York Mfg. Co., York, Pa.

Arch, Back Combustion Chamber

Mayville Specialty Mfg. Co, Mayville, Wis.

Arch, Boiler

McLeod & Henry Co., Troy, N. Y.

Arch, Boiler Door

Mayville Specialty Mfg. Co., Mayville, Wis
McLeod & Henry Co., Troy, N. Y.
Presbrey Fire Brick Co., Taunton, Mass.

Asbestos Goods

Carey Co., The Philip, Cincinnati, O
Johns-Manville Co., H. W., New York.

Babbitt Metal

Allan & Son, A., New York.
Phosphor-Bronze Smelting Co., Philadelphia, Pa.

Back Combustion Chamber Arch

McLeod & Henry Co., Troy, N. Y.

Bars, Boring Cylinder

Underwood & Co., H. B., Phila., Pa.

Belt Dressing

Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Garlock Packing Co., Palmyra, N. Y.
Johnson Co., Henry, Jersey City, N.J.
Rhoads & Son, J. E., Phila., Pa.
Shultz Belting Co., St. Louis, Mo.
Stephenson Mfg. Co., Albany, N. Y.
Walton Co., F. S., Philadelphia, Pa.

Belt Fasteners

Bristol Company, The, Waterbury, Conn.

Belt Lacing

Bristol Co., The, Waterbury, Conn.

Belting

Anchor Packing Co., Philadelphia, Pa.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.
Rhoads & Sons, J. E., Phila., Pa.
Robins New Conveyor Co., New York.
Shultz Belting Co., St. Louis, Mo.

Benders, Hydraulic

Watson-Stillman Co., New York.

Bends, Wrought Iron Pipe

Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Blowers

Beggs & Co., James, New York
De Laval Steam Turbine Co., Trenton, N. J.
Green Fuel Economizer Co., Matteawan, N. Y.
McClave-Brooks Co., Scranton, Pa.
Ohio Blower Co., Cleveland, O.
Sirocco Engineering Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Wing Mfg. Co., L. J., New York.

Blowers, Furnace

McClave-Brooks Co., Scranton, Pa.

Boiler Feeders

American Steam Pump Co., Battle Creek, Mich.
Davis Regulator Co., G. M., Chicago, Ill.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Lunkenheimer Co., Cincinnati, O
Myers & Bro., F. E., Ashland, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Boiler Fittings

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Boiler Skimmers

Buckeye Boiler Skimmer Co., Toledo, Ohio.

Boilers, Second Hand

Wickes Boiler Co., Saginaw, Mich.

Boilers, Tubular

Babcock & Wilcox Co., New York.
Beggs & Co., James, New York.
Edge Moor Iron Co., Edge Moor, Del.
Franklin Boiler Works Co., Troy, N. Y.
Griffith & Wedge Co., Zanesville, O.
Heine Safety Boiler Co., St. Louis, Mo.
Keeler & Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Oil Well Supply Co., Oswego, N. Y.
Phoenix Iron Works, Meadville, Pa.
Robb-Mumford Boiler Co., Amherst, N. S.
Struthers-Wells Co., Warren, Pa.

Power Plant "Allies"

The principal parts of a power plant are the boiler, the engine, the coal pile and the water supply.

In them and between them are large "holes" through which power, coal and water can escape.

The "Allies" of a power plant are appliances designed to stop those "holes" and keep the profits from leaking out.

WEBSTER STEAM SPECIALTIES are "allies" whose efficiency is world-famous.

They hold the power plant up to its highest-economy possibilities and, by preventing waste, they insure maximum profit.

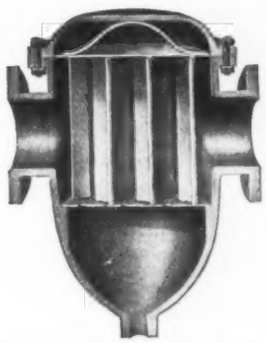
For example, WEBSTER FEED WATER HEATERS, PURIFIERS and FILTERS, heat feed water to the highest possible point, using just enough exhaust steam to gain that end. They operate on the vacuum principle and save power by preventing back pressure on the engine.

WEBSTER CHEMICAL PURIFIERS remove or neutralize all scale-forming impurities from the feed water while it is hot, and before it enters boilers.

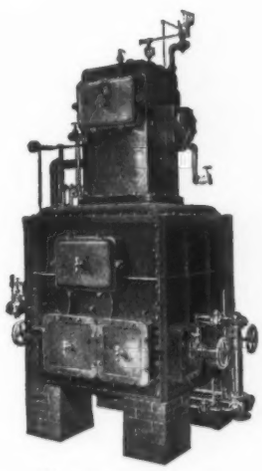
WEBSTER STEAM and OIL SEPARATORS remove moisture from steam supply-pipe and oil from exhaust steam.

It will pay you to know all about all the WEBSTER SPECIALTIES. Booklet 12-G describes them.

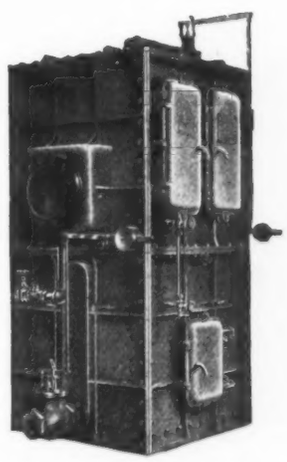
Warren Webster & Co.,
Camden, N. J.



Webster Standard Horizontal Oil Separator



Webster Chemical Purifier



Webster Feed Water Heater, Purifier and Filter

10

Boilers, Tubular—*Continued.*
Vilter Mfg. Co., Milwaukee, Wis.
Wetherill & Co., Robert, Chester, Pa.
Wickes Boiler Co., Saginaw, Mich.

Boilers, Water Tube
Babcock & Wilcox Co., New York.
Edge Moor Iron Co., Edge Moor, Del.
Franklin Boiler Works, Troy, N. Y.
Heine Safety Boiler Co., St. Louis, Mo.
Keeler Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Morrin Climax Boiler Co., Brooklyn, N. Y.
Oil Well Supply Co., Oswego, N. Y.
Parker Boiler Co., Philadelphia, Pa.
Phoenix Iron Works, Meadville, Pa.
Rust Boiler Co., Pittsburg, Pa.
Struthers-Wells Co., Warren, Pa.
Vogt Machinery Co., Henry, Louisville, Ky.
Wetherill & Co., Robt., Chester, Pa.
Wickes Boiler Co., Saginaw, Mich.

Books, Technical
American School of Correspondence, Chicago, Ill.
Hill Publishing Co., New York.
International Text Book Co., Scranton, Pa.

Building Materials, Fireproof
Carey Co., The, Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York.

Calorimeters
Sargent Steam Meter Co., Chicago, Ill.

Castings, Brass and Iron
Homestead Valve Mfg. Co., Pittsburg, Pa.
McClave-Brooks Co., Scranton, Pa.
Ohio Brass Co., Mansfield, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Castings, General
Neemes Bros., Troy, N. Y.

Castings, Malleable
Jeffrey Mfg. Co., Columbus, O.

Cement, Asbestos
Johns-Manville Co., H. W., New York.
N. Y. Belting & Packing Co., New York.

Cement, Boiler
Smooth-On Mfg. Co., Jersey City, N. J.

Chain Blocks
Yale & Towne Mfg. Co., New York.

Chimneys
Wiederholdt Construction Co., Chicago, Ill.

Chimneys, Reinforced Concrete
Wiederholdt Construction Co., Chicago, Ill.

Clamps, Steam Joint
McCrea & Co., James, Chicago, Ill.

Cleaners, Boiler Tube
Buckeye Boiler Skimmer Co., Toledo, Ohio.
Garlock Packing Co., Palmyra, N. Y.
General Specialty Co., Buffalo, N. Y.
Liberty Mfg. Co., Pittsburg, Pa.
Monarch Steam Blower Co., Troy, N. Y.
Pierce Co., Wm. B., Buffalo, N. Y.
Stewart Heater Co., Buffalo, N. Y.

Clocks, Engine Room
American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Clutches, Friction
Williams Fdry. & Mach. Co., Akron, Ohio.

Coal and Ash Handling Machinery
Bartlett & Snow Co., C. O., Cleveland, O.
Jeffrey Mfg. Co., Columbus, O.

Cocks, Blow-Off
Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Cocks, Gage
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Huyette Co., P. B., Philadelphia, Pa.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Reliance Gauge Column Co., Cleveland, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Cocks, Steam
Homestead Valve Mfg. Co., Pittsburg, Pa.
Williams Valve Co., D. T., Cincinnati, O.

Compound, Boiler
Bird-Archer Co., New York.
Buckeye Boiler Skimmer Co., Toledo, Ohio.
Dearborn Drug & Chemical Co., Chicago, Ill.
Hawk-Eye Compound Co., Chicago, Ill.
Johns-Manville Co., H. W., New York.

Compound, Lubricating
Cook's Sons, Adam, New York.

Condensers
Alberger Condenser Co., New York
American Steam Pump Co., Battle Creek, Mich.
Baragwanath & Son, Wm., Chicago, Ill.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Schutte & Koerting Co., Philadelphia, Pa.
Stewart Heater Co., Buffalo, N. Y.
Southwark Foundry and Machine Co., Philadelphia, Pa.
Wheeler Condenser and Engineering Co., New York.

Condensers, Gas
Phoenix Iron Works, Meadville, Pa.

Consumers, Smoke
Climax Smoke Preventer Co., Boston, Mass.

Controllers, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa

Cooling Towers
Alberger Condenser Co., New York.
Baragwanath & Sons, Wm., Chicago, Ill.
Wheeler Condenser and Engineering Co., New York.

Correspondence Schools
American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa,

Couplings, Clutch
Williams Fdry. & Mach. Co., Akron, Ohio

Covering, Pipe and Boiler
Carey Co., The Philip, Cincinnati, O.
Johns-Manville Co., H. W., New York.
U. S. Mineral Wool Co., New York.

Crabs
Yale & Towne Mfg. Co., New York.

Cranes
Yale & Towne Mfg. Co., New York.

Die Stocks
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., Cleveland, O.

District Steam Heating
American District Steam Co., Lockport, N. Y.

Draft, Mechanical
Green Fuel Economizer Co., Matteawan, N. Y.
Wing Mfg. Co., L. J., New York.

Drills, Upright
Barnes Co., W. F. & Jno., Rockford, Ill.

Dynamos and Motors, Alternating Current
Clark Bros. Co., Belmont, N. Y.
Crocker-Wheeler Co., Ampere, N. J.
Ft. Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Dynamos and Motors, Direct Current
Crocker-Wheeler Co., Ampere, N. J.
Ft. Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Triumph Electric Co., Cincinnati, O.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Economizers, Fuel
Green Fuel Economizer Co., Matteawan, N. Y.

Educational
American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa.

Ejectors
Beggs & Co., James, New York.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.

Electrical Engineers
Crocker Wheeler Co., Ampere, N. J.
Northern Electrical Mfg. Co., Madison, Wis.

Electrical Supplies
General Electric Co., Schenectady, N. Y.
Johns-Manville Co., H. W., New York.
Ohio Brass Co., Mansfield, Ohio.

Engineers' Supplies
Mound Tool & Scraper Co., St. Louis, Mo.

Engines, Corliss
Bates Machine Co., Joliet, Ill.
Beggs & Co., James, New York.
Cooper Co., C. & G., Mt. Vernon, O.
Griffith & Wedge Co., Zanesville, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Providence Eng. Works, Providence, R. I.
Southwark Foundry and Machine Co., Philadelphia, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Watertown Engine Co. Watertown, N. Y.
Wetherill & Co., Robert, Chester, Pa.
Wheeler Condenser & Engineering Co., New York.

Engines, Gas and Gasolene
Alberger Co., A. H., Buffalo, N. Y.
Buckeye Engine Co., Salem, Ohio.
De La Vergne Machine Co., New York.
Du Bois Iron Works, Du Bois, Pa.
Foos Gas Engine Co., Springfield, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Riverside Engine Co., Oil City, Pa.
Struthers-Wells Co., Warren, Pa.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, High Speed
American Engine Co., Bound Brook, N. J.
Ball Engine Co., Erie, Pa.
Bates Machine Co., Joliet, Ill.
Buckeye Engine Co., Salem, Ohio.
Clark Bros. Co., Belmont, N. Y.
Erie Mfg. & Supply Co., Erie, Pa.
Fitchburg Steam Eng. Co., Fitchburg, Mass.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Phoenix Iron Works, Meadville, Pa.
Reeves Engine Co., Trenton, N. J.
Shepherd Engineering Co., Williamsport, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Machine Co., Philadelphia, Pa.

Engines, High Speed—*Cont.*
Watertown Engine Co., Watertown, N. Y.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, Medium and Low Speed
Ball Engine Co., Erie, Pa.
Brown Engine Co., C. H., Fitchburg, Mass.
Buckeye Engine Co., Salem, Ohio.
Erie Mfg. & Supply Co., Erie, Pa.
Fitchburg Steam Engine Co., Fitchburg, Mass.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Phoenix Iron Works, Meadville, Pa.
Reeves Engine Co., Trenton, N. J.
Shepherd Engineering Co., Williamsport, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Mach. Co., Philadelphia, Pa.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, Oil
De La Vergne Machine Co., New York.

Engines, Rotary
Ball-Cooley Engineering Co., New York.

Exhaust Heads
Burt Mfg. Co., Akron, O.
Gardner Gov. & Separator Co., Quincy, Ill.
Hoppes Mfg. Co., Springfield, O.
Ohio Blower Co., Cleveland, O.
Pittsburgh Gage and Supply Co., Pittsburgh Pa.
Whitlock Coil Pipe Co. Hartford, Conn.

Fans, Electric
Ft. Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Triumph Electric Co., Cincinnati, O.
Westinghouse Elec. and Mfg. Co., Pittsburg, Pa.

Fans, Exhaust and Ventilating
Ohio Blower Co., Cleveland, O.
Sirocco Engineering Co., New York.

Fans, Mine Vetilating
Jeffrey Mfg. Co., Columbus, O.

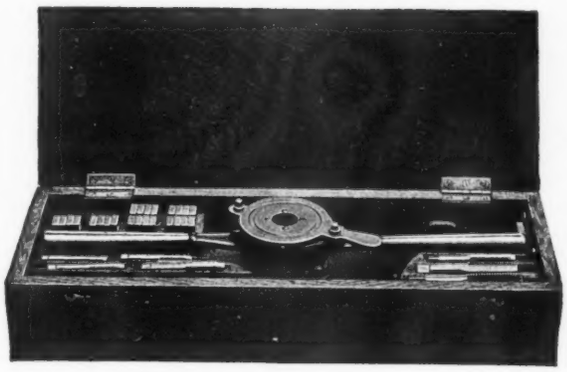
Feed Water Heaters and Purifiers
Alberger Condenser Co., New York.
Baragwanath & Son, Wm., Chicago, Ill.
Bates Machine Co., Joliet, Ill.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Erie Mfg. & Supply Co., Erie, Pa.
Goubert Mfg. Co., New York.
Griscom-Spencer Co., New York
Harrison Safety Boiler Wks., Philadelphia, Pa.
Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa.
Hoppes Mfg. Co., Springfield, O.
Kewanee Boiler Co., Kewanee, Ill.
Loew Mfg. Co., Cleveland, O.
National Pipe Bending Co., New Haven, Conn.
Patterson & Co., F. L., New York.
Phoenix Iron Works, Meadville, Pa.
Stewart Heater Co., Buffalo, N. Y.
Webster & Co., Warren, Camden, N. J.
Wheeler Condenser and Engineering Co., New York.
Whitlock Coil Pipe Co., Hartford, Conn.
Wickes Boiler Co., Saginaw, Mich

Filters, Feed Water
Beggs & Co., James, New York.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Keystone Chemical Co., Philadelphia, Pa.

Filters, Oil
Burt Mfg. Co., Akron, O.
Liberty Mfg. Co., Pittsburg, Pa.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Fire Brick
C-O-Two Furnace Co., Syracuse, N. Y.
McLeod & Henry Co., Troy, N. Y.
Presbrey Fire Brick Co., Taunton, Mass.

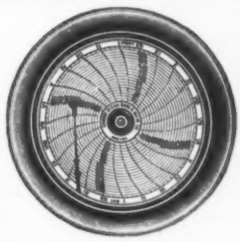
Oster
No. 21-C Screw Plate



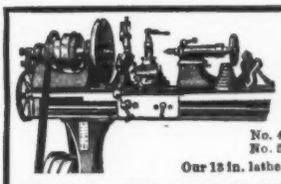
Threads bolts ¼ to ¾ Standard V. or U. S.
No bushings. No loose parts.
The guides are adjustable to all sizes.
The guides may be removed and the thread run close up to a shoulder.
Quality justifies double the price.

The Oster Mfg. Company,
21 Schiely Street, Cleveland, Ohio.

An Emphatic Success
CROSBY
RECORDING GAGES



ARE MADE BETTER than all others. Have special and important features which make them
INSTRUMENTS OF SUPERIOR WORTH.
They are faithful servants, working for you day and night
WE HAVE A LARGE VARIETY OF CHARTS OR WILL MAKE FOR SPECIAL PURPOSES
TRADE MARK CROSBY
Look them up before you purchase
CROSBY STEAM GAGE & VALVE CO.
BOSTON NEW YORK CHICAGO LONDON



"The BARNES"
LATHES
W.F. AND J.B.
9 in. to 13 in. Swing.
No. 4½ Lathe, 9 in. x 25 in., List $ 75.00
No. 5 Lathe, 11 in. x 34 in., List 100.00
Our 13 in. lathes made 5 to 10 feet long. Send for lathe catalog.
W. F. & JOHN BARNES CO., 990 Ruby Street, Rockford, Ill.

A BELTING WITHOUT LAPS, PLIES OR CEMENT
Robins Laminated Leather Belting is a continuous belt; perfectly balanced and non-stretchable. Circular No. 2 describes.
WRITE.
ROBINS NEW CONVEYOR COMPANY
New York, 38 Wall St. Factory, 168 Duane St. Chicago, Old Colony Bldg.

WHAT! NO INDICATOR?
Don't you know that I can give you a fine up-to-date outfit, new, from $25 00 up, and that I will let you pay a part of it acting as my agent in your spare time?
I will give you a thorough course of indicator instruction with a fine indicator to practice with for $5.00 per mo. Catalog?

Extra ¾ in. Area Cyl. for Ammonia, Gas Engine and high pressure work.
A. C. LIPPINCOTT, Newark, N. J.

THE HAWK-EYE BOILER COMPOUND
NEVER FAILED.
See our Advertisement in First Issue Every Month.

HAWK-EYE COMPOUND CO.,
303-304-305 Merrick Block, CHICAGO, ILL.

The Highest Authority on Steam Accounting
is the St. John Steam Meter—no other method of measuring steam gives such dependable results or gives its results in such convenient form.
The St. John records are permanent and suitable for filing away.
This meter is also adapted to the measurement of water, of air, and other gases.
WRITE TO-DAY
G. C. ST. JOHN
140 Cedar St., NEW YORK.

The St. John Indicating and Recording Steam Meter.

WEARWELL LEATHER PACKINGS

ALWAYS THE SAME.
Made in all sizes for Hydraulic and Compressed Air Machines.
Write for Catalog and Samples.
DETROIT LEATHER SPECIALTY CO., INC.,
175 Beecher Avenue, Detroit, Mich.

Fittings, Hydraulic

Watson-Stillman Co., New York.

Fittings, Pipe

Triumph Ice Machine Co., Cincinnati, Ohio.
Ohio Brass Co., Mansfield, O.

Flange Fittings, High or Low Pressure

Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Pittsburgh Valve & Fittings Co., Barberton, O.
Pittsburgh Valve, Foundry & Construction Co., Pittsburg, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Flanges

Central Station Steam Co., Detroit, Mich.

Floats

Anderson Co., V. D., Cleveland, O.
Reliance Gauge Column Co., Cleveland, O.

Furnace Tile

C-O-Two Furnace Co., Syracuse, N. Y.

Furnaces

Continental Iron Works, Brooklyn, N. Y.
Murphy Iron Works, Detroit, Mich.

Furnaces, Smokeless

McClave-Brooks Co., Scranton, Pa.
Murphy Iron Works, Detroit, Mich.
Wilkinson Mfg. Co., Bridgeport, Penn.

Gage Glasses

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Garlock Packing Co., Palmyra, N. Y.

Gage Testing Outfit

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Gages

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., The, Waterbury, Conn.
Crosby Steam Gage & Valve Co., Boston, Mass.
Huyette Co., Paul B., Philadelphia, Pa.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Gages, Ammonia

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Gages, Draft

Sargent Steam Meter Co., Chicago, Ill.

Gages, Pressure

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Williams Valve Co., D. T., Cincinnati, O.

Gages, Recording

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Gages, Vacuum

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Pittsburgh Gage and Supply Co., Pittsburgh, Pa.

Gages, Water

Ohio Brass Co., Mansfield, O.

Gaskets

American Goetze-Gasket & Packing Co., New York.
Anchor Packing Co., Philadelphia, Pa.
Brandt, Randolph, New York.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Jenkins Bros., New York.
Johns-Manville Co., H. W., New York.
Johnson Co., Henry, Jersey City, N. J.
National India Rubber Co., Bristol, R. I.
N. Y. Belting & Packing Co., New York.

Gaskets—*Continued.*

Quaker City Rubber Co., Philadelphia, Pa.
Smooth-On Mfg. Co., Jersey City, N. J.
U. S. Mineral Wool Co., New York.

Gaskets, Copper

Central Station Steam Co., Detroit, Mich.
Restein Co., Clement, Philadelphia, Pa.
U. S. Mineral Wool Co., New York.

Generating Sets

American Engine Co., Bound Brook, N. J.
Crocker-Wheeler Co., Ampere, N. J.
Foos Gas Engine Co., Springfield, Ohio.
Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Skinner Engine Co., Erie, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.
Watertown Engine Co., Watertown, N. Y.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Governors, Pump

Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Indianapolis, Ind.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Marshalltown, Iowa.
Foster Engineering Co., Newark, N. J.
Gardner, Governor & Separator Co., Quincy, Ill.
Strong, Carlisle & Hammond Co., Cleveland, O.

Graphite

Dixon Crucible Co., Jos., Jersey City, N. J.
Garlock Packing Co., Palmyra, N. Y.

Grates

Green Engineering Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Martin Grate Co., Chicago, Ill.

Grates, Clinker Cutting

Neemes Bros., Troy, N. Y.

Grates, Shaking and Dumping

McClave-Brooks Co., Scranton, Pa.
Martin Grate Co., Chicago, Ill.
Neemes Bros., Troy, N. Y.

Grates, Stationary

Gibson Iron Works Co. Jersey City, N. J.
Neemes Bros., Troy, N. Y.

Grease

Cook's Sons, Adam, New York.
Keystone Lubricating Co., Philadelphia, Pa.

Heating and Ventilating Apparatus

Green Fuel Economizer Co., Matteawan, N. Y.
Ohio Blower Co., Cleveland, O.
Webster & Co., Warren, Camden, N. J.

Hoists, Electric

Yale & Towne Mfg. Co., New York.

Hoists, Hand

Yale & Towne Mfg. Co., New York.

Hose, Air and Oil

Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Mercer Rubber Co., Hamilton Square, N. J.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Quaker City Rubber Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

Hose, Steam and Water

Anchor Packing Co., Philadelphia, Pa.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.
Mercer Rubber Co., Hamilton Square, N. J.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.

Hose, Steam and Water—*Continued.*

Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.
Restein Co., Clement, Philadelphia, Pa.

Indicators, Ammonia

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Indicators, Gas Engine

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Indicators, Hydraulic

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Indicators, Speed

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Starrett Co., L. S., Athol, Mass.

Indicators, Steam Engine

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Lippincott Steam Specialty and Supply Co., Newark, N. J.
Robertson & Sons, James L., New York.
Trill Indicator Co., Corry, Pa.

Injectors

American Injector Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, O.
Ohio Injector Co., Wadsworth, O.
Penberthy Injector Co., Detroit, Mich.
Randle Mach. Co., Cincinnati, O.
Schutte & Koerting Co., Philadelphia, Pa.

Insulation

Johns-Manville Co., H. W., New York.

Jacks, Hydraulic

Watson-Stillman Co., New York.

Joints, Expansion

Central Station Steam Co., Detroit, Mich.

Lamps, Arc and Incandescent

Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Locks

Yale & Towne Mfg. Co., New York.

Lubricants

Cook's Sons, Adam, New York.
Dearborn Drug & Chemical Wks., Chicago, Ill.
Dixon Crucible Co., Jos., Jersey City, N. J.
Keystone Lubricating Co., Philadelphia, Pa.

Lubricators

Cook's Sons, Adam, New York.
Detroit Lubricator Co., Detroit, Mich.
Greene, Tweed & Co., New York.
Lunkenheimer Co., Cincinnati, O.
Ohio Lubricator Co., Wadsworth, O.
Philadelphia Lubricator & Mfg. Co., Philadelphia, Pa.

Machinery, Conveying

Bartlett & Snow Co., C. O., Cleveland, O.
Jeffrey Mfg. Co., Columbus, O.

Machinery, Crank Pin Turning

Underwood & Co., H. B., Philadelphia, Pa.

Machinery, Ice and Refrigerating

De La Vergne Machine Co., New York.
Triumph Ice Machine Co., Cincinnati, Ohio.
Vilter Mfg. Co., Milwaukee, Wis.
York Mfg. Co., York, Pa.

Machinery, Second Hand

Randle Mach. Co., Cincinnati, O.

Machines, Blue Printing

Buckeye Engine Co., Salem, Ohio.

Machines, Portable Milling

Underwood & Co., H. B., Philadelphia, Pa.

Machines, Valve Reseating

Leavitt Mach. Co., Orange, Mass.

Mats and Matting

Mercer Rubber Co., Hamilton Square, N. J.

Mechanical Draft Apparatus

Green Fuel Economizer Co., Matteawan, N. Y.

Mechanical Stokers

Westinghouse Machine Co., Pittsburg, Pa.
Wilkinson Mfg. Co., Bridgeport, Pa.

Metal, Anti-friction

Allan & Son, A., New York.
St. John, G. C., New York.

Metal Polish

Hoffman, Geo. W., Indianapolis, Ind.

Meters, Water

Blake Mfg. Co., Geo. F., New York.
Deane Steam Pump Co., Holyoke, Mass.

Meters, Steam

Sargent Steam Meter Co., Chicago, Ill.

Oil Burners

Hammel Oil Burner Co., Los Angeles, Cal.

Oil and Grease Cups

Cook's Sons, Adam, New York.
Greene, Tweed & Co., New York.
Keystone Lubricating Co., Philadelphia, Pa.
Lunkenheimer Co., The, Cincinnati, O.
Philadelphia Lubricator & Mfg. Co., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, O.

Oilers

Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Oiling Systems

Burt Mfg. Co., Akron, O.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.

Oils

Cook's Sons, Adam, New York.
Dearborn Drug & Chemical Wks., Chicago, Ill.

Packing, Asbestos

Diamond Rubber Co., Akron, Ohio.
Johns-Manville Co., H. W., New York.
Johnson Co., Henry, Jersey City, N. J.
Mercer Rubber Co., Hamilton Square, N. J.
Restein Co., Clement, Philadelphia Pa.

Packing, Flange

American Goetze-Gasket & Packing Co., New York.
Brandt, Randolph, New York.
Carey Co., The Philip, Cincinnati, O.
Diamond Rubber Co., Akron, Ohio.
Eureka Packing Co., New York.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Jenkins Bros., New York.
Johns-Manville Co., H. W., New York.
Mercer Rubber Co., Hamilton Square, N. J.
N. Y. Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Phila., Pa.
Restein Co., Clement, Phila., Pa.
Vanda Co., New York.

Packing, Hydraulic

Anchor Packing Co., Philadelphia, Pa.
Brandt, Randolph, New York.
Detroit Leather Specialty Co., Detroit, Mich.
Diamond Rubber Co., Akron, Ohio.
Garlock Packing Co., Palmyra, N. Y.

The Tracing of Motor Troubles

is no longer a hit-or-miss proposition; no longer a matter of guesswork; no longer the thing to be dreaded that it once was. And this revolution has come about through a book called

Motor Troubles

Written by E. B. Raymond, Electrical Engineer of the General Electric Company

In it the greatest expert in the country gives you the benefit of his wide experience; shows you the quickest, easiest and best methods for tracing, locating and correcting direct-current and alternating-current motor troubles and for testing direct- and alternating-current machinery.

Tells the whole story of Starting Up; Sparking; Brush Troubles; Characteristics of the Induction Motor; Locating Faults in Induction Motors; Winding Faults; Balking of Induction Motors; Mechanical Troubles; Troubles with Synchronous Motors; Testing Generators; Testing Direct-Current Motors; Testing Induction Motors, etc. Illustrates every point necessary.

This remarkable new book should be in the hands of every engineer handling motors if he would sidestep the burden of time- and labor- and money-wasting difficulties that come with motor troubles.

$1.50 is the price of the book postpaid. If you'll send $1.50 we'll ship the book at once and then, if you're not entirely satisfied, return your money provided you send back the book in good condition within 5 days of receipt.

Think for a minute of the practical helpfulness of such a book, of the difficulties you'll be relieved of the next time your motors develop trouble, and order TODAY.

Hill Publishing Company
505 Pearl Street, New York

Power *American Machinist*
The Engineering and Mining Journal

CLING-SURFACE Co Buffalo N Y

Gentlemen—We are using Cling-Surface for our belts and could not do without it.

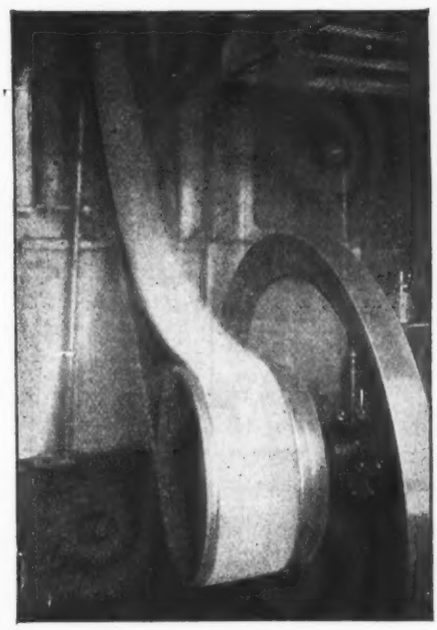
We could barely credit the pictures of loose belts which you sent us before we began with Cling-Surface, but now send you one of ours.

It is a painted canvas belt, which was very dry and stiff and slipped badly before we had used Cling-Surface. Now it is in fine condition, pliable, clean and does not slip, as the photo shows.

It is 8" wide, 3-ply, on 14' centers, from a 20" iron to 14" wood pulley. Does 12-14 H. P. drives from Ohio gas engine 220 R. P. M. Cling-Surface has been used since early in 1906.

It now runs so slack that the sag will almost touch the bottom yet never slips.

Yours very truly
PRINCE HANDLE & MFG Co
A I PRINCE



Cling-Surface For Cotton Belts

Cling-Surface is just as good for cotton belts as for others.

The only difference is in the treatment.

Unpainted (plain cotton) it penetrates into, making them firm, pliable, absolutely water-proof, so that they won't stretch nor contract, can be run in water.

Painted varieties (like Gandy, Leviathan and others) it penetrates into more slowly, but prevents cracking, makes them pliable and waterproof and in best condition.

All varieties will stop slipping and can be run easy or slack and carry full loads.

Remember that where belts are really loaded, Cling-Surface is the only way to let them be run easy, with all that means, and pull.

We guarantee Cling-Surface to do it. Read about this belt. Then write us.

Cling-Surface Company
1049 Niagara Street Buffalo N Y

New York Boston Denver Atlanta
Chicago St. Paul St Louis Memphis etc

London Thomas & Bishop 119-125 Finsbury Payment E C

Packing, Hydraulic—*Cont.*
Johns-Manville Co., H. W., New York.
Johnson Co., Henry, Jersey City, N. J.
Mabbs Hydraulic Packing Co., Chicago, Ill.
Mercer Rubber Co., Hamilton Square, N. J.
Quaker City Rubber Co., Phila., Pa.
Restein Co., Clement, Phila., Pa.
Robertson & Sons, Jas. L., New York.
Steel Mill Packing Co., Detroit, Mich.
Vanda Co., New York.

Packing, Metallic
American Goetze-Gasket & Packing Co., New York.
Anchor Packing Co., Philadelphia, Pa.
Canfield Mfg. Co., Philadelphia, Pa.
Houchin-Aiken Co., Brooklyn, N. Y.
Johns-Manville Co., H. W., New York.
Mercer Rubber Co., Hamilton Square, N. J.
Monarch Steam Blower Co., Troy, N. Y.
Power Specialty Co., New York.
Restein Co., Clement, Phila., Pa.

Packing, Piston Rod
American Goetze-Gasket & Packing Co., New York.
Anchor Packing Co., Philadelphia, Pa.
Canfield Mfg. Co., Philadelphia, Pa.
Carey Co., The Philip, Cincinnati, O.
Diamond Rubber Co., Akron, Ohio.
Eureka Packing Co., New York.
Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Johns-Manville Co., H. W., New York.
National India Rubber Co., Bristol, R. I.
New York Belting and Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Phila., Pa.
Restein Co., Clement, Phila., Pa.
Robertson & Sons, Jas. L., New York.
Steel Mill Packing Co., Detroit, Mich.
Underwood & Co., H. B., Philadelphia, Pa.
Vanda Co., New York.

Packing, Pneumatic
Diamond Rubber Co., Akron, Ohio.
Mercer Rubber Co., Hamilton Square, N. J.
Restein Co., Clement, Phila., Pa.

Packing, Pump
National India Rubber Co., Bristol, R. I.

Packing, Pump Valve
Anchor Packing Co, Philadelphia, Pa.

Packing, Rod
Anchor Packing Co., Philadelphia, Pa.

Pipe
Central Station Steam Co., Detroit, Mich.

Pipe Bending
Harrisburg Pipe & Pipe Bending Co., Harrisburg, Pa.
National Pipe Bending Co., New Haven, Conn.
Pittsburgh Gage & Supply Co., Pittsburgh Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Pipe Clamp
Simplex Engineering Co., Philadelphia, Pa.

Pipe Cutters
Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keller Mfg. Co., Edwardsville, Ill.
Borden Co., Canton, O.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., The, Cleveland, O.
Trimont Mfg. Co., Roxbury, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Pipe Joints
Pittsburgh Valve & Fittings Co., Barberton, O.
Pittsburgh Valve, Foundry & Construction Co., Pittsburg, Pa.
Whitlock Coil Pipe Co., Hartford, Conn.

Pipe Threading Machines
Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Borden Co., Canton, O.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., The, Cleveland, O.
Toledo Pipe Threading Machine Co., Toledo, O.
Trimont Mfg. Co., Roxbury, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Planimeters
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Lippincott Steam Specialty and Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.

Power Transmission
Jeffrey Mfg. Co., Columbus, O.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Saginaw Mfg. Co., Saginaw, Mich.

Presses, Hydraulic
Watson-Stillman Co., New York.

Producers, Gas
Broomell, Schmidt & Steacey Co., York, Pa.
De La Vergne Machine Co., New York.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Westinghouse Mach. Co., Pittsburg, Pa.

Publishers
American School of Correspondence, Chicago, Ill.
Hill Publishing Co., New York.
International Correspondence Schools, Scranton, Pa.

Pulleys
Myers & Bro., F. E., Ashland, O.
Saginaw Mfg. Co., Saginaw, Mich.

Pulleys, Clutch
Williams Fdry. & Mach. Co., Akron, Ohio.

Pumps, Air
American Steam Pump Co., Battle Creek, Mich.
Blake Mfg. Co., Geo. F., New York.
Deane Steam Pump Co., Holyoke, Mass.
Wheeler Condenser & Engineering Co., New York.

Pumps, Boiler Feed
American Steam Pump Co., Battle Creek, Mich.
Kewanee Boiler Co., Kewanee, Ill.

Pumps, Centrifugal
Wheeler Condenser & Engineering Co., New York.

Pumps, Compound
American Steam Pump Co., Battle Creek, Mich.
Deane Steam Pump Co., Holyoke, Mass.

Pumps, Deep Well
American Steam Pump Co., Battle Creek, Mich.
Blake Mfg. Co., Geo. F., New York.
Deane Steam Pump Co., Holyoke, Mass.

Pumps, Electric
American Steam Pump Co., Battle Creek, Mich.
Blake Mfg. Co., Geo. F., New York.
Deane Steam Pump Co., Holyoke, Mass.

Pumps, Force-feed Oil
Greene, Tweed & Co., New York.
Lunkenheimer Co., Cincinnati, O.

Pumps, Hydraulic
American Steam Pump Co., Battle Creek, Mich.
Blake Mfg. Co., Geo. F., New York.
Deane Steam Pump Co., Holyoke, Mass.
Watson-Stillman Co., New York.

Pumps, Mining
American Steam Pump Co., Battle Creek, Mich.
Blake Mfg. Co., Geo. F., New York.
Deane Steam Pump Co., Holyoke, Mass.

Pumps, Oil
American Steam Pump Co., Battle Creek, Mich.
Deane Steam Pump Co., Holyoke, Mass.
Deming Co., The, Salem, O.
Detroit Lubricator Co., Detroit, Mich.
Du Bois Iron Wks., Du Bois, Pa.
Lunkenheimer Co., Cincinnati, Ohio.
Penberthy Injector Co., Detroit, Mich.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Warren Steam Pump Co., Warren, Mass.

Pumps, Steam
American Steam Pump Co., Battle Creek, Mich.
Blake Mfg. Co., Geo. F., New York.
Deane Steam Pump Co., Holyoke, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Du Bois Iron Works, Du Bois, Pa.
Gardner Gov. & Sep. Co., Quincy, Ill.
McGowan Co., John H., Cincinnati, O.
Myers & Bro., F. E., Ashland, O.
Stewart Heater Co., Buffalo, N. Y.
Warren Steam Pump Co., Warren, Mass.
Wheeler Cond. & Eng. Co., New York.
Worthington, Henry R., New York.

Pumps, Triplex
Deming Co., The, Salem, O.

Pumps, Turbine
Alberger Condenser Co., New York.

Pumps, Vacuum
American Steam Pump Co., Battle Creek, Mich.
Wheeler Condenser & Engineering Co., New York.

Punches, Hydraulic
Watson-Stillman Co., New York.

Purifiers, Live Steam
Hoppes Mfg. Co., Springfield, O.

Purifiers, Water
Buckeye Boiler Skimmer Co., Toledo, Ohio.
Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Keystone Chemical Co., Phila., Pa.
Whitlock Coil Pipe Co., Hartford, Conn,

Pyrometers
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., The, Waterbury, Conn.

Re-cooling Plants
De La Vergne Machine Co., New York.
Schutte & Koerting Co., Philadelphia, Pa.

Recording Instruments
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., The, Waterbury, Conn.
Crosby Steam Gage and Valve Co., Boston, Mass.

Reducing Wheels
American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Lippincott Steam Specialty and Supply Co., Newark, N. J.
Robertson & Sons, Jas. L., New York.
Trill Indicator Co., Corry, Pa.

Refrigeration Machinery
De La Vergne Machine Co., New York.
Triumph Ice Mach. Co., Cincinnati, O.
Vilter Mfg. Co., Milwaukee, Wis.
York Mfg. Co., York, Pa.

Regulators, Damper
Berry Engineering Co., Chester, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Kitts Mfg. Co., Oswego, N. Y.
Lagonda Mfg. Co., Springfield, O.

Regulators, Damper—*Cont.*
Robertson & Sons, Jas. L., New York.
Watson & McDaniel Co., Phila., Pa.

Regulators, Feed Water
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Phila., Pa.

Regulators, Pressure
Davis Co., John, Chicago, Ill.
Davis Regulator Co., G. M., Chicago, Ill.
Dean Bros. Steam Pump Works Indianapolis, Ind.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Marshalltown, Iowa.
Foster Engineering Co., Newark, N. J.
Mason Regulator Co., Boston, Mass.
Ohio Brass Co., Mansfield, O.
Robertson & Sons, Jas. L., New York.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Phila., Pa.

Regulators, Water
Foster Engineering Co., Newark, N. J.

Repairs, Engine and Pump
Underwood & Co., H. B., Philadelphia, Pa.

Reseating Machines, Flue Cap
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.

Reseating Machines, Valve
Leavitt Mach. Co., Orange, Mass.

Rope Dressing
Cling-Surface Co., Buffalo, N. Y.

Rubber Goods
Diamond Rubber Co., Akron, Ohio
Garlock Packing Co., Palmyra, N. Y
Greene, Tweed & Co., New York.
Mercer Rubber Co., Hamilton Square, N. J.
National India Rubber Co., Bristol, R. I.
New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Phila., Pa.
Restein Co., Clement, Phila., Pa.

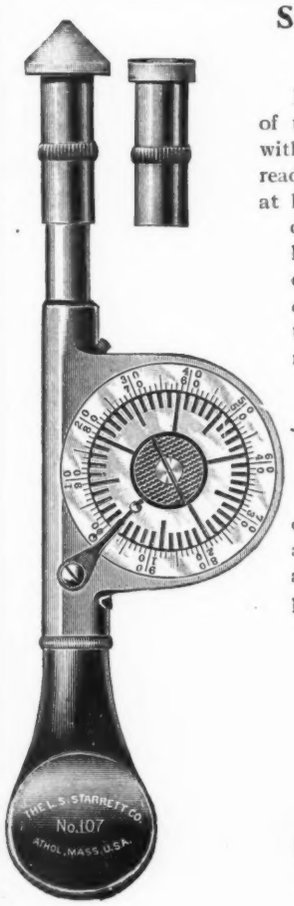
Schools, Correspondence
American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa.

Separators and Extractors, Steam and Oil
Baragwanath & Son, Wm., Chicago, Ill.
Beggs & Co., Jas., New York
d'Este Co., Julian, Boston, Mass.
Direct Separator Co., Syracuse, N. Y.
Goubert Mfg. Co., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Ohio Blower Co., Cleveland, O.
Patterson & Co., F. L., New York.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.
Robertson & Sons, Jas. L., New York.
Watson & McDaniel Co., New York.
Webster & Co., Warren, Camden, N. J.
Wheeler Condenser & Engineering Co., New York.
Whitlock Coil Pipe Co., Hartford, Conn.
Williams Valve Co., D. T., Cincinnati, O.

Sheathing
Carey Co., The Philip, Cincinnati, Ohio.
Johns-Manville Co., H. W., New York.

Skylights
Burt Mfg. Co., Akron, O.

DO YOU want these tools delivered to your doorstep FREE? If you're a subscriber to POWER AND THE ENGINEER, you're in line to get them. If you are not a subscriber, you'll be in line as soon as you subscribe. All subscribers are entitled to these premiums if they secure NEW subscriptions for POWER AND THE ENGINEER.



Starrett's Registering Speed Indicator

Made in the best possible manner, of the best materials and is fitted with a dial having two rows of figures reading either right or left. Will run at highest speed of machinery without heating and has hard rubber handle for insulation when used on electrical machinery. It *automatically* registers the number of revolutions up to 5000 so that the hundreds do not have to be kept in mind.

Given for two WEEKLY subscriptions

The Victor Pipe Wrench

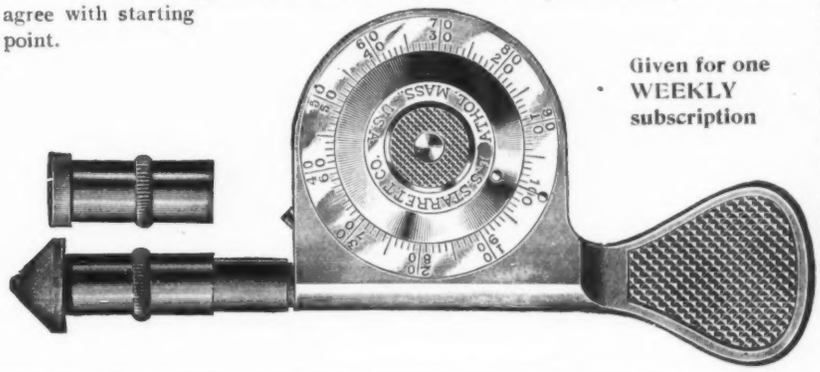
This wrench will take pipe from ¼ to 1 inch; is made of tool steel and so designed that the jaw will always hold firm in place, yet can be adjusted instantly with one hand. You will find it the most convenient pipe tool that you ever used.

Given for one WEEKLY subscription

Starrett's High Speed Indicator

May be run at highest speed required without heating. Working parts inclosed. Dial plate has two rows of figures, reading right or left. By pressure and twist of thumb, plate is loosened and "0" mark may be instantly moved to agree with starting point.

Given for one WEEKLY subscription



Remember: No premiums are given for renewal subscriptions. You must be a subscriber and the subscriptions must be NEW ones.

Getting these valuable and useful engine room tools will prove easy for YOU. You know POWER AND THE ENGINEER; know its value; know its practical helpfulness to every engineer. All you've got to do is to go to a fellow engineer with this copy of the paper. Tell him what you think of it, why he should subscribe, and you'll get his order sure. Send us the money and the addresses and we'll forward you the premium you select.

Here's a pointer: Do it TO-DAY.

Published weekly, you know, at $2.00 a year.

505 Pearl St., POWER AND THE ENGINEER NEW YORK

Smoke Preventers

Climax Smoke Preventer Co., Boston, Mass.

Specialties, Steam

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
American District Steam Co., Lockport, N. Y.
Baragwanath & Son, Wm., Chicago, Ill.
Berry Engineering Co., Chester, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Marshalltown, Ia.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Lippincott Steam Specialty and Supply Co., Newark, N. J.
Lunkenheimer Co., Cincinnati, Ohio.
McCrea & Co., James, Chicago, Ill.
Nason Mfg. Co., New York.
Ohio Brass Co., Mansfield, Ohio.
Patterson & Co., F. L., New York.
Penberthy Injector Co., Detroit, Mich.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Reliance Gauge Column Co., Cleveland, O.
Restein Co., Clement, Philadelphia, Pa.
Robertson & Sons, Jas. L., New York.
Stephenson Mfg. Co., Albany, N. Y.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Phila., Pa.
Webster & Co., Warren, Camden, N. J.

Steam Heating Supplies

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Erie Mfg. & Supply Co., Erie, Pa.
Foster Engineering Co., Newark, N. J.
Ohio Blower Co., Cleveland, O.
Ohio Brass Co., Mansfield, Ohio.

Stocks and Dies

Armstrong Mfg. Co., Bridgeport, Conn.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Borden Co., Canton, O.
Curtis & Curtis Co., Bridgeport, Conn.
Loew Mfg. Co., Cleveland, O.
Oster Mfg. Co., The, Cleveland, O.
Toledo Pipe Threading Machine Co., Toledo, O.

Stokers

Green Engineering Co., Chicago, Ill.
McClave-Brooks Co., Scranton, Pa.
Westinghouse Mach. Co., Pittsburg, Pa.
Wilkinson Mfg. Co., Bridgeport, Pa.

Stokers, Mechanical

McClave-Brooks Co., Scranton, Pa.

Storage Batteries

Westinghouse Machine Co., Pittsburg, Pa.

Strainers

Dean Bros. Steam Pump Works, Indianapolis, Ind.
Foster Engineering Co., Newark, N. J
Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, O.

Superheaters, Steam

Babcock & Wilcox Co., New York.
Parker Boiler Co., Phila., Pa.
Power Specialty Co., New York.
Providence Eng. Wks., Providence, R. I.
Whitlock Coil Pipe Co., Hartford, Conn.

Switchboards, Light and Power

Fort Wayne Electric Works, Ft. Wayne, Ind.
General Electric Co., Schenectady, N. Y.
Northern Electrical Mfg. Co., Madison, Wis.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Switches, Electric

General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Syphons, Acid

Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Sherwood Mfg. Co., Buffalo, N. Y.

Tanks

Phoenix Iron Works, Meadville, Pa.

Taps and Dies

Toledo Pipe Threading Mach. Co., Toledo, Ohio.

Temperature Regulators

d'Este Co., Julian, Boston, Mass.

Thermometers, Feed Water

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Bristol Co., The, Waterbury, Conn.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Tools, Scraping

Mound Tool & Scraper Co., St. Louis, Mo.

Track, Overhead

Yale & Towne Mfg. Co., New York.

Transformers and Converters

General Elec. Co., Schenectady, N.Y.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Traps

Anchor Packing Co., Philadelphia, Pa.
Anderson Co., V. D., Cleveland, O.
Central Station Steam Co., Detroit, Mich.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Jenkins Bros., New York.
Kitts Mfg. Co., Oswego, N. Y.
McCrea & Co., James, Chicago, Ill.
Morehead Mfg. Co., Detroit, Mich.
Nason Mfg. Co., New York.
Ohio Blower Co., Cleveland, O.
Platt & Co., John, New York.
Reliance Gauge Column Co., Cleveland, O.
Schutte & Koerting Co., Phila., Pa.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Phila., Pa.
Williams Valve Co., D. T., Cincinnati, O.

Trucks, Storage Battery Auto-

Westinghouse Machine Co., Pittsburg, Pa.

Tube Cleaners

General Specialty Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
McCrea & Co., James, Chicago, Ill.
Pierce Co., Wm. B., Buffalo, N. Y.
Robertson & Sons, Jas. L., New York.
Sherwood Mfg. Co., Buffalo, N. Y.

Tube Cleaner Rods

McCrea & Co., James, Chicago, Ill.

Tube Cutters

Lagonda Mfg. Co., Springfield, O.

Tubing

Johns-Manville Co., H. W., New York.
Peerless Rubber Mfg. Co., New York.
Pennsylvania Flexible Metallic Tubing Co., Philadelphia, Pa.

Turbines, Steam

De Laval Turbine Co., Trenton, N. J.
General Electric Co., Schenectady, N. Y.
Westinghouse Machine Co., Pittsburg, Pa.

Unions

Lunkenheimer Co., Cincinnati, Ohio.
Pittsburg Valve and Fittings Co., Barberton, O.
Williams Valve Co., D. T., Cincinnati, O.

Valves

Amer. Steam Gauge & Valve Mfg. Co., Boston, Mass.
Ashton Valve Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Davis Regulator Co., G. M., Chicago, Ill.
Foster Engineering Co., Newark, N. J.
Jenkins Bros., New York.

Valves—*Continued.*

Liberty Mfg. Co., Pittsburg, Pa.
Lunkenheimer Co., Cincinnati, Ohio.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Valve & Fittings Co., Barberton, O.
Pittsburgh Valve, Foundry & Construction, Co. Pittsburg, Pa.
Schutte & Koerting Co., Philadelphia, Pa.
Walch & Wyeth, Chicago, Ill.
Watson & McDaniel Co., Philadelphia, Pa.

Valves, Automatic Cut-off

Lagonda Manufacturing Co., Springfield, O.
Walch & Wyeth, Chicago, Ill.

Valves, Automatic Relief

Walch & Wyeth, Chicago, Ill.

Valves, Back Pressure

Best Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Foster Engineering Co., Newark, N. J.
Jenkins Bros., New York.
Pittsburgh Valve, Foundry and Construction Co., Barberton, O.
Walch & Wyeth, Chicago, Ill.

Valves, Blow-off

Homestead Valve Mfg. Co., Pittsburg, Pa.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.

Valves, Check

Walch & Wyeth, Chicago, Ill.

Valves, Cylinder Relief

Amer. Steam Gauge and Valve Mfg. Co., Boston, Mass.
Crosby Steam Gage & Valve Co., Boston, Mass.
Davis Regulator Co., G. M., Chicago, Ill.
Lunkenheimer Co., Cincinnati, O.

Valves, Drain

Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Exhaust Relief

Walch & Wyeth, Chicago, Ill.

Valves, Float

Foster Engineering Co., Newark, N. J.
Homestead Valve Mfg. Co., Pittsburg, Pa.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Valves, Free Exhaust

Schutte & Koerting Co., Philadelphia, Pa.

Valves, Gate

Central Station Steam Co., Detroit, Mich.
Lunkenheimer Co., Cincinnati, O.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Valve and Fittings Co., Barberton, O.
Pittsburgh Gage & Supply Co., Pittsburgh, Pa.
Walch & Wyeth, Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, O.

Valves, Hydraulic

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Watson-Stillman Co., New York.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Iron Stop

Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Non-return

Walch & Wyeth, Chicago, Ill.

Valves, Pop Safety

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Ashton Valve Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, O.

Valves, Pump

Garlock Packing Co., Palmyra, N. Y.

Valves, Reducing

Davis Regulator Co., G. M., Chicago, Ill.
Mason Regulator Co., Boston, Mass.
Ohio Brass Co., Mansfield, Ohio.
Watson & McDaniel Co., Philadelphia, Pa.

Valves, Regrinding

Lunkenheimer Co., Cincinnati, O.
Pittsburgh Valve and Fittings Co., Barberton, O.
Strong, Carlisle & Hammond Co., Cleveland, O.
Williams Valve Co., D. T., Cincinnati, O.

Valves, Regulating

Fisher Governor Co., Marshalltown, Iowa.
Ohio Brass Co., Mansfield, Ohio.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Valves, Relief

Amer. Steam Gauge & Valve Mfg. Co., Boston, Mass.
Ashton Valve Co., Boston, Mass.
d'Este Co., Julian, Boston, Mass.
Jenkins Bros., New York.
Lunkenheimer Co., Cincinnati, O.
Peerless Rubber Mfg. Co., New York.
Power Specialty Co., New York.
Quaker City Rubber Co., Philadelphia, Pa.
Wheeler Condenser & Engineering Co., New York.

Valves, Safety

Amer. Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Valves, Safety Gate

Walch & Wyeth, Chicago, Ill.

Valves, Stop Check

Schutte & Koerting Co., Philadelphia, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Swing Gate

Walch & Wyeth, Chicago, Ill.
Williams Valve Co., D. T., Cincinnati, Ohio.

Valves, Water Relief

American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., The, Cincinnati, O.

Ventilators

Burt Mfg. Co., Akron, O.
Ohio Blower Co., Cleveland, Ohio.

Vises

Armstrong Mfg. Co., Bridgeport, Conn.

Water Columns and Alarms

American Steam Gauge and Valve Mfg. Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.
Reliance Gauge Column Co., Cleveland, O.

Water Filtration and Softening Plants

Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Harrison Safety Boiler Wks., Philadelphia, Pa.

Whistles

Williams Valve Co., D. T., Cincinnati, Ohio.

Whistles, Chime

American Steam Gauge & Valve Mfg Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Winches

Yale & Towne Mfg. Co., New York.

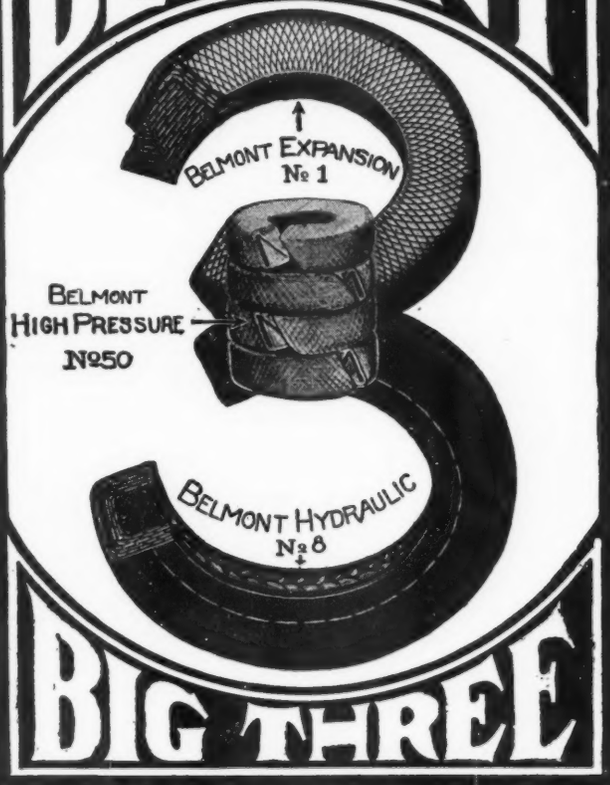
Wrenches

Curtis & Curtis Co., Bridgeport, Conn.
Trimont Mfg. Co., Roxbury, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Wrenches, Pipe

Armstrong Mfg. Co., Bridgeport Conn.

BELMONT



BIG THREE

Three good friends needed by every engineer are.

BELMONT "1903" EXPANSION PACKING, Style No. 1, with three break joints, which, when joined, makes practically a solid ring. For shallow stuffing boxes this packing cannot be equaled, as a single ring will prevent escape of steam. Especially suitable for **ammonia** and **steam** up to 125 lbs. pressure. Write for booklet A.

BELMONT HIGH PRESSURE WEDGE PACKING, Style No. 50, composed of two asbestos sliding wedges from which all metallic particles have been removed by the magnetic process, and a back containing a ruober compound which is absolutely unaffected by highest steam pressures. Lubricated by best special high test lubricating compound, in connection with best graphite. The only safe packing for **high pressure** or **superheated steam.** Write for booklet B.

BELMONT "1903" SPECIAL HYDRAULIC PACKING, Style No. 8, (for hot or cold water), consists of a casing of finest cotton duck and rubber, around three sides of a braided flax core. This packing is stitched through and through crosswise, hence, cannot be twisted out of shape—cannot pinch or swell. For any kind of pumping service, but on the **water end only, not for steam.** Unaffected by alkalis, oils or sulphuric acid mine water. Write for booklet C.

We manufacture packings for every known purpose. General catalog free on request.

FREE

Sample Ring of either of these three packings free. Fill in coupon with name of kind wanted.

FREE! SEND FOR A SAMPLE RING AND BE CONVINCED.

CLEMENT RESTEIN CO., Philadelphia, Pa.
Gentlemen:—Send me a sample ring of.....
.....
Name.....
Address.....
Firm Name.....
Number of Engines.....
Number of Pumps.....
Number of Boilers.....
High or Low Pressure.....
Packing Now in use.....

Power, Sept. 01.

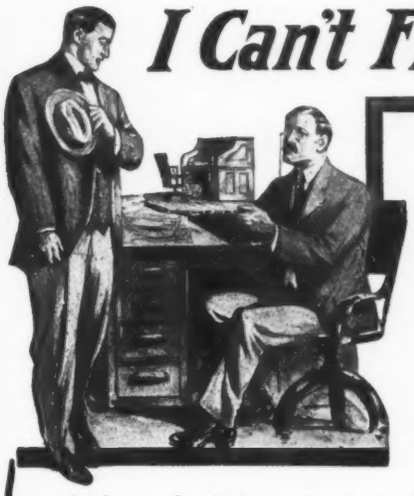
CLEMENT RESTEIN CO.

133 North Second Street, PHILADELPHIA, PA.

SALESMEN WANTED.

To call at power plants, pumping stations and engine rooms, and sell BELMONT PACKINGS and Specialties. Particularly attractive proposition for manufacturers, agents and engineers in territory not already covered. CLEMENT RESTEIN CO., 133 North Second Street, Philadelphia, Pa.

I Can't Fill It



IF a good position were offered **you** today, would you have to "turn it down" because you lack the necessary qualifications? Even if you accepted the position, could you hold it—or would your lack of training compel you to step out in favor of a **better** trained man?

How can you expect a successful career unless you build it on a good foundation? **Utilize your spare moments—study at home**—fit yourself **properly** to meet opportunity—then you will succeed. The American School of Correspondence will tell you how if you'll clip the coupon and mail it **today.**

SPECIAL HELP TO ENGINEERS

The AMERICAN SCHOOL OF CORRESPONDENCE has given hundreds of Stationary Engineers and Firemen, Oilers, Electrical Engineers, Draftsmen, Heating and Ventilating Engineers, and Plumbers just the special training which they needed to qualify for lucrative positions. Our courses in Stationary Engineering, Electrical Engineering, Locomotive Engineering, Drafting, Heating, Ventilating and Plumbing are as complete and practical as they can be made. Besides giving the most comprehensive instruction in the usual work, we teach the construction of **boilers and engines.** We give special attention to shop drawing and machine design.

We employ no agents. We talk to you only by mail. The money you pay is not used to maintain an expensive organization of high-priced agents, but is used to give you the **best** instruction at the **lowest** cost.

The American School of Correspondence is the only correspondence school in the country which makes a **specialty** of engineering instruction. Its instructors are practical men—men who have had years of actual experience in their special fields. Consult these experienced men—get their advice—profit by their years of hard experience. Let them help you plan a **paying** career. *Remember,* **sending the coupon places you under no obligations.**

American School of Correspondence
Chicago

.....**COUPON**—Clip and mail today..... .....

Power, 9-8-08.

American School of Correspondence:

Please tell me how I can fit myself to earn a good salary in the line of work marked "X."

—Special Engineer's Course (Preparatory to License Examinations)	—Contractor and Builder
—Steam Engineer	—Surveyor
—Resid nt Engineer	—Telephone Engineer
—Heating and Ventilating Engineer	—Hydraulic Engineer
—Electrical Engineer	—Irrigation Engineer
—Boiler and Sheet Metal Pattern Draftsman	—Mechanical Engineer
—Civil Engineer	—Superintendent of Construction
—Architect	—Pattern Draftsman
—Architectural Draftsman	—Structural Draftsman
	—City Engineer
	—Bridge Engineer
	—College Preparatory Course

Name.....

Address.....

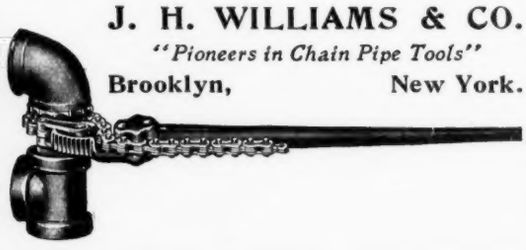
Occupation.....

Discarded Features

See the chain? Sense will tell you that its weight alone will release it from its locking pockets, and in working overhead this is matter of extreme danger and importance when in elevated positions. We will not offer make-shifts and death-traps. Years ago we discarded the one side chain fastening feature. Now it is being advertised as a new thing, permitting shifts from right to left without removing from pipe. It will permit shifts, but not with safety in all positions. The chain-wrench business has been our study for a lifetime.

In the **"Agrippa"** we have a combination of safety, strength and universal utility that cannot be beaten.

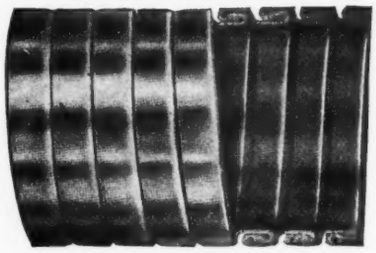
Guaranteed and on trial from dealer.



J. H. WILLIAMS & CO.

"Pioneers in Chain Pipe Tools"

Brooklyn, New York.



Asbestos Packed Throughout.

PENNSYLVANIA

FLEXIBLE METALLIC TUBING

is able to hold superheated steam at the highest pressures. The interlocking edges give it a flexibility far superior to that of rubber hose.

Made in all sizes from $\frac{1}{8}$" to 12", and is used for all purposes where high pressure is necessary, and also for all liquids, compressed air, gases, etc.

PENNSYLVANIA FLEXIBLE METALLIC TUBING CO.,

S. H. COLLOM H. A. ANSELL

1305 Arch Street, Philadelphia, Pa.

New York, 86 Warren St. Boston, 71 High St. Chicago, 225 LaSalle St.

How do you do your Hoisting

In Yale & Towne Chain Blocks

are embodied the final development in lifting mechanism and the highest integrity in Chain Block construction. They lead in efficiency, speed, durability, reliability and universal adaptation to every hoisting requirement.

Triplex Blocks—½ to 40 tons. Universally recognized as the most durable and efficient Chain Block made. Have balanced train of spur Gearing with large internal gear.

Duplex Blocks—½ to 10 tons. The handiest and fastest Screw Blocks made. Have safety guides to prevent slipping of load chains. Bronze Worm wheels and steel worms with hardened and ground thrust bearings running in oil.

Differential Blocks—½ to 3 tons. Not as durable or easy lifting as the Triplex or Duplex, but safe and twice as durable as the cheaper kind of the Weston Differential Block, because of superior Chain and Sheaves.

Y. & T. Blocks, duplicate parts and trolleys are carried in stock by Hardware, Machinery and Mill Supply Dealers. Write for catalog.

The Yale & Towne Mfg. Co.,

9 Murray Street, New York.

HYDRAULIC JACKS

Every type of first class thoroughly guaranteed Hydraulic Jacks for all classes of work are manufactured by us.

Over 400 different types and sizes from 2 to 1000 tons capacity.

Each and every tool guaranteed.

Send for Jack Catalog No. 68.

Watson Stillman Co.,

50 Church St. New York City.

Chicago Office, 453 Rookery.

PEERLESS SPIRAL PISTON AND VALVE ROD PACKING

IS THE MOST SATISFACTORY PACKING IN THE WORLD.
IT WILL RUN FROM 12 TO 16 MONTHS WITHOUT REPACKING.
WILL HOLD 400 POUNDS OF STEAM.
IT WILL PACK TIGHTLY ANY ROD HOWEVER BADLY SCORED AND CORRODED.
WILL NOT GET HARD UNDER ANY DEGREE OF HEAT.

SOLE MANUFACTURERS OF THE CELEBRATED
RAINBOW PACKING

PATENTED MANUFACTURED EXCLUSIVELY BY

THE PEERLESS RUBBER MANUFACTURING COMPANY

16 WARREN ST., NEW YORK

DETROIT, MICH. - 16-24 WOODWARD AVE.
CHICAGO, ILL. - 202-210 SO. WATER ST.
PITTSBURG, PA. - 425-427 FIRST AVE.
SAN FRANCISCO, CAL. 131 153 KANSAS ST.
NEW ORLEANS, LA. COR. COMMON & TCHOUPITOULAS STS.
ATLANTA GA. - 7-9 SOUTH BROAD ST.
KANSAS CITY, MO. - 1221-1223 UNION AVE.

SEATTLE, WASH - RAILROADWAY & OCCIDENTAL AVE
LOUISEVILLE, KY - 111-121 W. MAIN ST.
INDIANAPOLIS, IND - 16-18 SQ. CAPITOL AVE
OMAHA, NEB. - 12 18 FARNAM ST.
DENVER, COL. - 1723-1731 BLAKE ST.
RICHMOND, VA. - COR. NINTH & CAREY STS.
WACO, TEXAS - 709-711 AUSTIN AVE.

BOSTON, MASS. - 110 FEDERAL ST.
BUFFALO, 379-383 WASHINGTON ST.
MILWAUKEE, WIS. 96-100 SECOND ST.
SYRACUSE, N.Y. - 212-214 SO. CLINTON ST.
LOS ANGELES, CAL. - 115 SO. LOS ANGELES ST.
PORTLAND, ORE. - 14-16 FIRST ST.
BALTIMORE, MD. - 37 HOPKINS PLACE.

FOREIGN DEPOTS

LONDON E.C., ENGLAND. - 58 HOLBORN VIADUCT
PARIS FRANCE. - 76 AVE DE LA REPUBLIQUE.
SYDNEY, AUSTRALIA. - 270 GEORGE ST.
JOHANNESBURG, SOUTH AFRICA. - 2427 MERCANTILE BL'D'G
COPENHAGEN, DEN - FREDERIKSHOLMS KANAL 6.
VANCOUVER, B.C. - CARRAL & ALEXANDER STS.

Tearing Off Pipe Coverings

simply to tighten up the flange bolts, where short-lived packings have been used, is expensive business and it

Can Be Avoided By Using Everlasting TAURIL

the Sheet Packing that has a tensile strength of over 3 tons per square inch and withstands a compressive strain of 14 tons, still retaining its elasticity.

"Tauril" is equally efficient for Steam, Air, Water, Ammonia, Acids, Gases, Motor Car Joints and all kinds of Gas Engine Work at the very highest temperatures and pressures.

Write for details and prices.

The Anchor Packing Company,

Main Office and Factory: Allegheny, Sedgeley and Germantown Aves., Philadelphia, Pa.

NEW YORK Branch, 1353 Hudson Terminal Bldg., 50 Church St. PITTSBURGH Branch, 667 Frick Bldg. Annex. CHICAGO Branch, 410 Railway Exchange. BALTIMORE Branch, 514 Continental Bldg. HAZLETON, PA., Branch, 15 North Wyoming St. DETROIT Branch, Ford Bldg.

Representatives in all Industrial Centres

Cobbs High Pressure Spiral Piston and Valve Stem Packing

The Rubber core is made of an oil and heat resisting compound, wrapped with a well frictioned Duck, with an outer cover of fine asbestos, lubricated by our secret process.

It is made round or square, in coil or spiral form especially adapted to withstand heat and high pressure. We guarantee "Cobbs" Packing will pack any rod perfectly tight, as it will not get hard under any degree of heat.

"Cobbs" Packing also furnished in rings at short notice, made of round or square packing.

Indestructible White Sheet Packing

Is without doubt the toughest and most durable High Pressure Sheet Packing on the market. It will stand the highest pressure and extreme heat, making a tight joint when used for Steam, Air, Hot or Cold Water.

It does not dry out or become hard and brittle, but retains its tough elastic qualities, either in or out of service. Ammonia, Liquor, Alkali, Oils or Acids have little or no effect on it, and joints can be broken numerous times without renewing the packing.

Indestructible White Sheet Packing is also made with wire insertion.

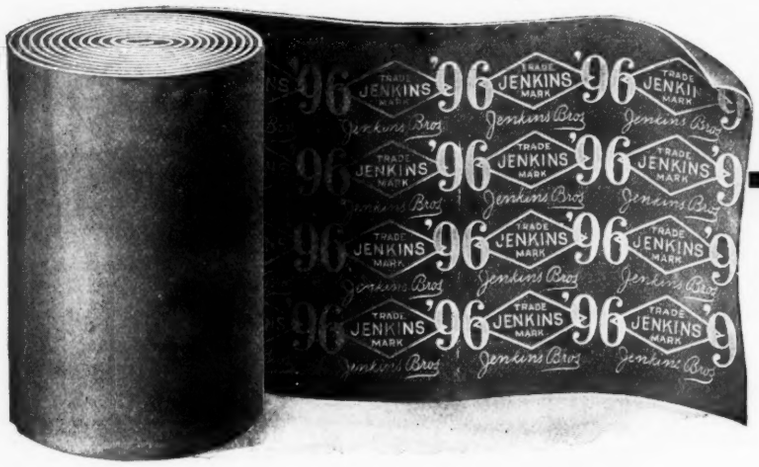
We manufacture a complete line of high class rubber goods, comprising Beltmg, Air, Fire, Garden, Steam, Suction, Pneumatic Tool and Water Hose Packings, Gaskets, Mats, Matting, Stopples, Special Mould Goods, Interlocking Rubber Tiling, Tubing, etc.

SOLE MANUFACTURERS

New York Belting & Packing Company, Ltd.

91 and 93 Chambers Street, New York, N. Y.

CHICAGO, 150 Lake St.
ST LOUIS, 218-220 Chestnut St.
PHILADELPHIA, 118-120 N. 8th St.
SAN FRANCISCO, East 11th St and 3d Ave., OAKLAND.
BOSTON, 232 Summer St
INDIANAPOLIS, 229 S Meridian St.
BALTIMORE, 114 W. Baltimore St.
BUFFALO, 600 Prudential Bldg.
PITTSBURG, 913 915 Liberty Ave.
SPOKANE, WASH., 163 S. Lincoln St.
LONDON, E. C., ENGLAND, 58 Holborn Viaduct.



JENKINS '96

is the most *economical* packing to use

Because

The *weight* per square yard is less than most sheet packings. Comparison with similar sizes of other packings—even if sold at a lower price per pound—will often show that Jenkins '96 *costs less per square yard.*

Because

The scrap that is left after cutting out the gaskets can be returned to our factory, and credit allowance will be made.

Because

For durability it is unequaled, and when a joint has once been made it will last for years without further attention, saving loss of steam, time and temper.

Write for Samples and Prices.

JENKINS BROS.

71 John Street, New York.

133 No. 7th St., Philadelphia.

226-228 Lake St., Chicago.

35 High St., Boston.

95 Queen Victoria St., London.

Eureka Packing

Is Head And Shoulders Above Ordinary Kinds

Eureka Packing is so carefully and scientifically made, of such high grade material, that it greatly outlasts other makes. It has thoroughly proved its ability to reduce friction to lowest point and to make perfectly tight joints, and it requires less repacking than any other. With all these superior features Eureka costs about one-third less than other high-grade packings.

We also make Cut Ring, High Pressure, Water Proof Hydraulic in rings and coils, Spiral and Red Sheet Packings. Send for samples and prices.

THIS LABEL ON PACKING "EUREKA" TRADE MARK. IS A GUARANTEE OF EXCELLENCE.

Eureka Packing Company,

Sales Department,

Jas. L. Robertson, Pres't **46 Warren St., New York.**

The Robertson-Thompson Indicator Leads

the way to highest possible engine economy by supplying accurate records of exactly how much power is being developed, etc. Its authenticity is perfectly reliable. Sold on easy terms when desired. Details? The Willis Planimeter is all that a planimeter should be.

Jas. L. Robertson & Sons,

46 Warren St., New York.

ENGINEERS WHO HAVE USED

INDIAN RED SHEET PACKING

Will tell you it has the
STAYING AND RESISTING QUALITIES

It is efficient in every respect
which, in the end, means economy.

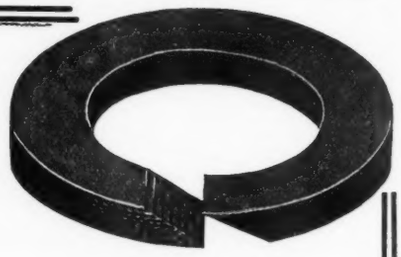
A 14 x 28 hanger, like cut herewith, but in colors,
free to any engineer upon request.

The DIAMOND RUBBER CO., AKRON, OHIO.

Complete Diamond Stocks Carried By

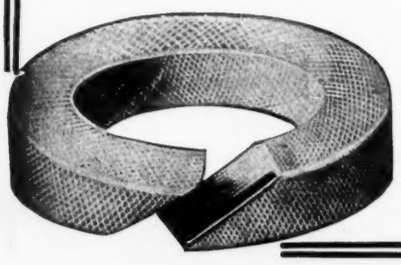
The Diamond Rubber Co. of N. Y.,
1876 Broadway, N. Y.
The Diamond Rubber Co.,
1523 Michigan Ave., Chicago, Ill.
The Diamond Rubber Co.,
Mission and 2nd Sts., San Francisco, Cal.
Buffalo Mill Supply Co.,
Buffalo, N. Y.
Southern Hardware & Supply Co.,
Mobile, Ala.
Consumers Rubber Co.,
Cleveland, Ohio.
The Diamond Rubber Co. of N. Y.,
304 N. Broad St., Philadelphia, Pa.
The Diamond Rubber Co.,
3963 Olive St., St. Louis, Mo.
The Gustin-Bacon Manufacturing Co.,
Kansas City, Mo.
Pittsburgh Rubber & Leather Co.,
Pittsburgh, Pa.
Alabama Machinery & Supply Co.,
Montgomery, Ala.
M. I. Wilcox Co.,
Toledo, Ohio.

GENEROUS QUANTITIES OF SPLENDID MATERIAL AND EXPERT WORKMANSHIP



are the prime features of **JOHNSON'S PACKINGS** which make them standard for all purposes.

Ask for our catalog, it is an invaluable reference book for every user of packings.



THE HENRY JOHNSON CO.,

175-187 Gates Avenue,

JERSEY CITY, NEW JERSEY.

VANDA

A STEAM PACKING THAT IS A STEAM PACKING

TRADE MARK. REG. IN U. S. PAT. OFF.

All Goods Stamped with the VANDA TRADE-MARK will fulfill the claims we make for them.

VANDA SHEET PACKING

THIS PACKING IS THE PIONEER OF ALL COMPOSITION PACKINGS, AND IMITATORS ARE APPEARING IN GREAT NUMBERS. WE THEREFORE, WOULD ESPECIALLY CALL YOUR ATTENTION TO OUR

TRADE-MARK DEVICE STAMPED ON EVERY SHEET

GOODS MADE IN SHEETS ONLY OF 4½' x 4½' AND 4½' x 9', IN ALL THICKNESSES

THE VANDA COMPANY, 96 SPRING STREET, N. Y.

H. W. JOHNS-MANVILLE CO., CO-DISTRIBUTORS

AMBEST METALLIC PACKING, FOR

Ambest TRADE MARK

The *new* and *practical*

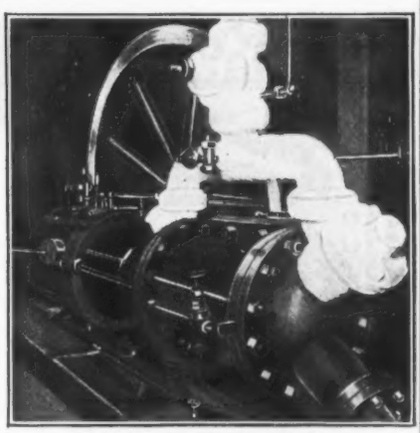
METALLIC PACKING

is composed of long pliable filaments of a secret non-friction metal, treated with our special lubricating compound.

It is as frictionless as oil, contains absolutly no materials that can in any possible manner cut or score a rod, and any size rod or stem may be packed from the same can.

The very best packing for

AMMONIA



AMMONIA COMPRESSORS

The peculiar excellence of Ambest packing for ammonia is attested by the following letter which came unsolicited to Laib Company, Agents for "Ambest" in the State of Kentucky.

LAIB CO.,
Louisville, Ky.

Georgetown, Ky., Sept. 20th, 1906.

Dear Sirs:—After trying several of the most expensive and most highly recommended packings on our own Ammonia Pumps and failing to get results from their use, we were induced by your Mr. Craft to give your AMBEST packing a trial under a guarantee. We did so, but after our previous experience, expected it to fail also; but we have been most agreeably surprised at the results obtained by its use, having used it for the past two months and there has never been the least trace of a leak, while our weekly expense heretofore for packing for three pumps was more than the initial expense of the AMBEST, not to mention the loss from AMMONIA leakage.

Very truly yours,
Royal Spring Ice Co.

FREE (Fill out this coupon and mail it to us).

CANFIELD MFG CO.,
Philadelphia, Pa.

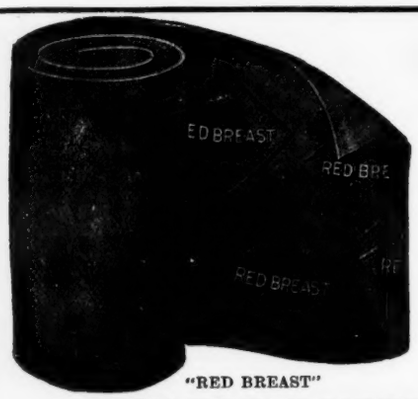
Gentlemen:—
You may send me, free of charge, a sample of Ambest Metallic Packing.

Name . . . . . .
Address . . . . . .
Firm Name . . . . . .
No. of Engines . . . . . .

Total H.P. . . . . . .
No. of Pumps . . . . . .
High or Low Pressure . . . . . .
Packing now in use . . . . . .

Power, Sept. 1908

CANFIELD MFG. CO., PHILADELPHIA, PA.



"RED BREAST"

Red Breast Packing

A Standard Red Sheet Packing—Will not crack or harden under any degree of heat; absolutely impervious to the influence of alkalies, oils and Ammonia; positively won't contract or expand; and will withstand the highest pressure.

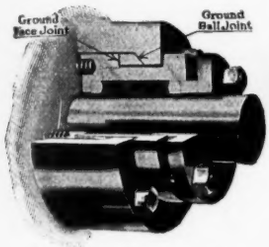
Write for Free Sample

This Packing is better than others—far better—and, better still, is low priced. We will gladly send samples **Free** upon request.

MERCER RUBBER CO., Hamilton Square, New Jersey

Branch Offices—Philadelphia, 421 Arcade Bldg. New York, 250 Fulton St. Pittsburg, 8th and Liberty Sts. Denver 610 Exchange Bldg., and Chicago, 40 Dearborn St.

VIBRATING STUFFING BOX



"It Floats with the Rod"

"SAFETY"

PLASTIC

Metallic Packing

FOR STEAM, WATER, AIR, GAS, HYDRAULIC MACHINES, VALVES, ETC.

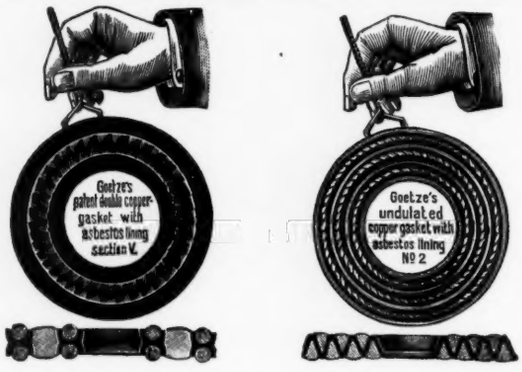
Guaranteed to stand Steam Temperature up to 550 degrees F. and Hydraulic Pressure to 5,000 lbs. per square inch.

HIGHEST AWARD WORLD'S FAIR, ST. LOUIS.

Send for Free Sample and Particulars

Manufactured Solely by STEEL MILL PACKING COMPANY, Detroit, Mich., U. S. A.

For Rough Flanges


Goetze's patent double copper gasket with asbestos lining section V.
Goetze's undulated copper gasket with asbestos lining No 2

Goetze's Elastic Copper Gaskets

are lined with asbestos and will fit snugly and remain tight at any pressure or degree of superheat. They last for years and may be used repeatedly.

We'll send you the necessary sample—FREE.

American Goetze-Gasket & Packing Co.
525 East 149th Street, New York, N. Y.

Here's a jolly engineer parading with the boys
She's out to have a lot of fun, and doesn't mind the noise,
But like the rest she knows what's best, and bears aloft a banner
That says: *Black Squadron can't be beat* in any shape or manner.

BLACK SQUADRON

This packing with four wedges, one of them a lubricated flax and rubber cushion, is the *latest* and *best* achievement in packing design and manufacture.

It is made on the same principle as a universal chuck, and has the same wonderful ability to meet every possible irregularity of the rod or stuffing box. It gives greatest rod pressure with minimum friction and minimum gland pressure. It permits fifty per cent. of draw, thereby enabling BLACK SQUADRON to outlast ordinary packings several times over. Other advantages too numerous to mention here. Write for free catalog.

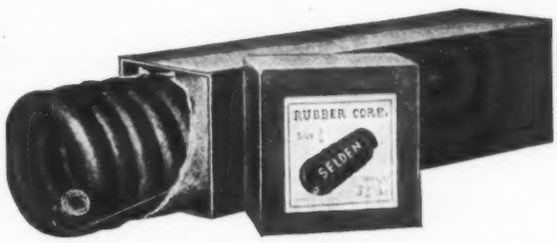
CANCOS MFG. CO., PHILADELPHIA, PA.

10 Oliver St., Boston, Mass. 525 Third Ave, Pittsburg, Pa.
805 Plowman St., Baltimore, Md.

NIR

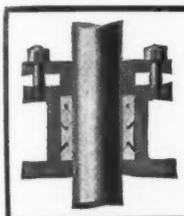
RED SHEET PACKING
MECHANICAL RUBBER GOODS
"THE BEST EVER"
NATIONAL INDIA RUBBER CO.
Bristol, R. I.
BRANCHES: New York, Chicago, Boston, Baltimore, Buffalo.

YOU DON'T PAY EITHER WAY,



If you are not entirely satisfied you don't pay. If you are perfectly satisfied Selden does pay. Write.

Randolph Brandt, 72 Cortlandt St., New York.

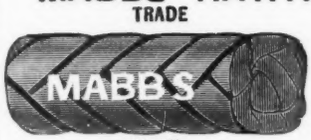


The Only Packing

that is capable of perfect lubrication is Law Metallic Packing. Circular?

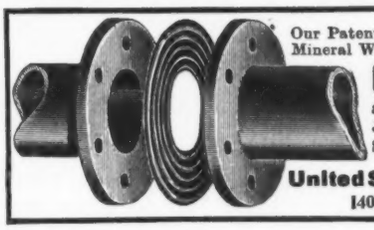
HOUCHIN-AIKEN CO.,
SOLE M'F'R'S
113-121 Fifty-Third St., B'klyn, N.Y.

MABBS RAWHIDE PACKING



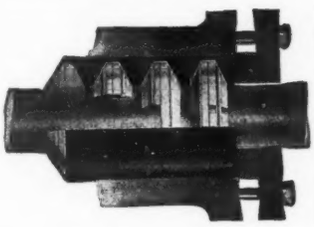
The Pack'ng for Water Works, Stern Pipes of Propellors; Deep Mine Pumps, Air Drills, Ice Machines and all machinery using cold water

Mabbs Hydraulic Packing Co.,
Box 829. CHICAGO.



Our Patented Mineral Wool **Pipe Covering and Copper Gaskets** Save Steam and Make Absolutely Tight Joints. Best and Cheapest. Samples Free.

United States Mineral Wool Co.
140 Cedar Street, New York



It keeps the Rods smooth and lasts as long as the Engine

STERLING METALLIC PACKING is far superior to any other. It is designed to stand any pressure and is made in three section rings, each ring being a valve seat in itself, elastic and easily worked. It will not corrode the rod when the engine is idle and pays its cost over and over in the saving of soft packing bills. Every inch of our packing is made to order, fully guaranteed and sold on trial. **Write for catalog.**

MONARCH STEAM BLOWER CO., - Troy, N. Y.

Carey's 85 per cent Carbonate Magnesia Coverings

THE largest contract ever awarded for steam pipe and boiler coverings specified Carey's. This was the result of an exhaustive test conducted by the Manhattan Railway Company of New York, which proved Carey's Coverings to be more efficient and far superior in every way to any other of the numerous makes. No other coverings proved to be as light, clean and substantial.

Carey's Coverings are absolutely fire-proof, and being thorough non-conductors of heat they confine the heat to the pipes, effectually preventing its loss through radiation, thus saving in fuel an amount sufficient to *more* than offset the cost of their application.

The most prominent steam users everywhere use Carey's Covering. Do you want to know why?

Send for Carey's Magnesia Catalogue. It gives information not obtainable elsewhere.

THE PHILIP CAREY COMPANY

General Offices: Station R, Cincinnati, O.
FACTORIES: Lockland, Ohio; Plymouth Meeting, Pa.
Branches and Warerooms:

New York: 114-118 Liberty Street.
St. Louis: 908 North 2nd Street.
Baltimore, Md.: 332-334 North Street.
Philadelphia, Pa.: 12th and Buttonwood Sts.
Toronto, Canada: 112 Bay Street, East.
Cleveland, Ohio: 123 Water Street.
Buffalo, N. Y.: 45 Pearl Street.
Pittsburg, Pa.: 333-335 Second Avenue.
Atlanta, Ga.: 34 West Alabama Street.
Charlotte, N. C.: East 7th and R. R. Streets.
New Orleans, La.: 222 Chartres Street.

Tulley's Handbook

"This is the Book That I Wouldn't Take $50.00 for if I Couldn't Get Another!"

The fifty-dollar man is conservative. Right in this office today are letters from buyers of **Tulley's Handbook** saying that $100 couldn't buy their copy unless they knew where to get another. ¶ Yet these well pleased engineers stood where you stand today—they hesitated about buying. Our "money-back" guarantee reassured them and they ordered the book. Are they satisfied? At the head of this page is the answer. ¶ Consider what they got, what you will get for your money when you buy

Tulley's Handbook

On a thousand pages are the condensed, crystallized contents of thirty ordinary books. These pages are brimful of facts covering *every* phase of steam and electrical engineering. There's not a question that will arise, not a problem about your work come up, but that the correct answer will be found in **Tulley's Handbook.** Why! When you think of the practical helpfulness of such a book in your everyday work, and when you are looking for a license, $15.00 would seem a small price for it. It's actual cost is only $3.50 ¶ Remember, that above all else, this book is practical from start to finish. No Latin nor Greek; no higher mathematics; no "frills." Just plain and understandable engine-room English and simple arithmetic. Over 400 illustrations. Pages of tables that save hours of figuring. Pages of questions usually asked in examinations. Bound in flexible leather.

GUARANTEE

This guarantee is given with every copy sold. It means what it says. It protects you from loss and gives you the opportunity to examine Tulley's Handbook at your leisure. Take advantage of it. Send us $3.50. We'll send you the book postpaid. If you're not entirely satisfied, return the book in good condition within 5 days of receipt and we'll refund your money at once without question or quibble.

E-2

Cut Off Here and Mail Now

Mail this today.

HILL PUBLISHING COMPANY, 505 Pearl Street, New York City

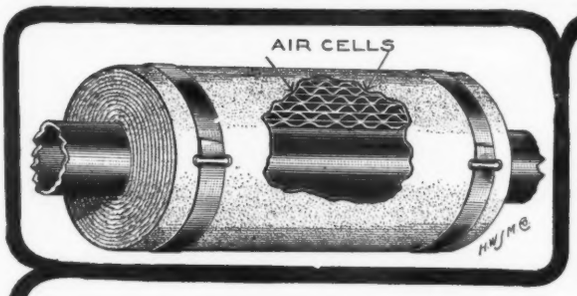
Enclosed find $3.50
Send Tulley's Handbook subject to your guarantee.

Name .....
St. & No. .....
City & State .....

HILL PUBLISHING COMPANY

505 Pearl Street, New York City

Power and The Engineer
American Machinist. *The Engineering and Mining Journal*



Economize In Heating

The greatest factor in economical heating is an efficient pipe covering. When steam or hot water are delivered through uncovered or poorly insulated pipes, the loss by radiation and condensation, and the consequent waste of fuel, is enormous. Unfortunately, radiation and condensation cannot be observed, consequently, many who realize the necessity of covering pipes, do not realize that many pipe coverings are but little better than none and are only deceiving.

Are you sure that your heating system is being operated as economically as it could be, and that your pipe covering is not merely a *covering* rather than an *insulator?* Why not let us examine your plant, without any obligation to you, and give you an expert opinion as to whether your heating system could be operated more economically by covering the pipes with

ASBESTOCEL PIPE COVERING

For Hot Water, and Low and Medium Pressure Steam

ASBESTOCEL costs practically the same as ordinary pipe covering but is many times as efficient, because it is made on a different principle.

The insulating properties of pipe covering depend on the amount of dead (motionless) air it confines. ASBESTOCEL is built on the principle of an arch, with the air cells running around the pipe, preventing the circulation of air; while other coverings have the cells running from end to end, allowing the air to travel back and forth. By actual tests ASBESTOCEL has shown that it will pay for itself in fuel saved in an average of eight and a half months.

Being made of Asbestos, it is light in weight, fireproof and not affected by heat, dampness, acid or chemical fumes. It cannot crack, break or lose its insulating efficiency from rough handling or vibration. It is as good an insulator at the end of ten years as when first put on.

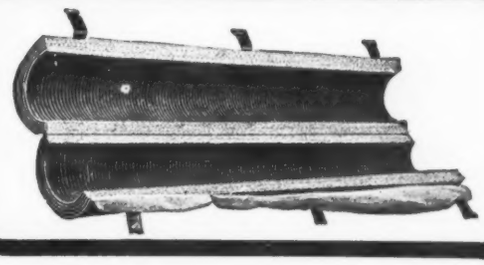
May we send you sample and booklet and furnish you with further information without charge? Write nearest Branch now, before you forget it.

H. W. JOHNS-MANVILLE CO.

Manufacturers of Asbestos and Magnesia Products, Asbestos Roofings, Packings, Electrical Supplies, Etc.

New York	St. Louis	Baltimore	Los Angeles
Milwaukee	Pittsburg	New Orleans	Seattle
Chicago	Cleveland	Kansas City	Dallas
Boston	Buffalo	Minneapolis	Toronto
Philadelphia	Detroit	San Francisco	London

875



A Whirling Motion

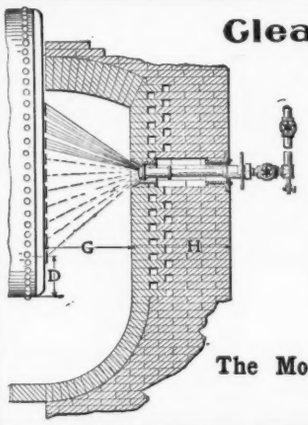
imparted to the exhaust steam by the

GARDNER EXHAUST HEAD

causes all oil and condensation to separate and drain off. No baffle plates are required and back pressure is impossible.

WRITE.

The Gardner Governor and Separator Co.,
QUINCY, ILLINOIS.



Clean Tubes and Clean Profits

go hand in hand.

A Monarch Steam Flue Blower blows out the soot in the direction of the natural draft. It is permanently installed in the brick work and always ready for business. Cleans the tubes in just five minutes.

Write.

The Monarch Steam Blower Co.
Troy, New York

The
"SWARTWOUT"
CAST IRON EXHAUST HEAD

has come to stay, and it will stay for a life-time. You can't rust it out; you can't dent it or break it. You wouldn't be without it for the world after you've once studied the principles of its design.

The advantages are simply told in the new catalogue—the finest steam specialty catalogue ever published. You may have it for the asking.

THE OHIO BLOWER CO.
CLEVELAND, OHIO

Also manufacturers of "Swartwout" Gravity-Closing Ventilators. 1-48

Protect Your Plant From Fire And Your Men From Injury

by preventing bursted boiler tubes. More tubes rupture from overheating than from any other cause. Overheating results from an insulating layer of scale or greasy deposit within the tube.

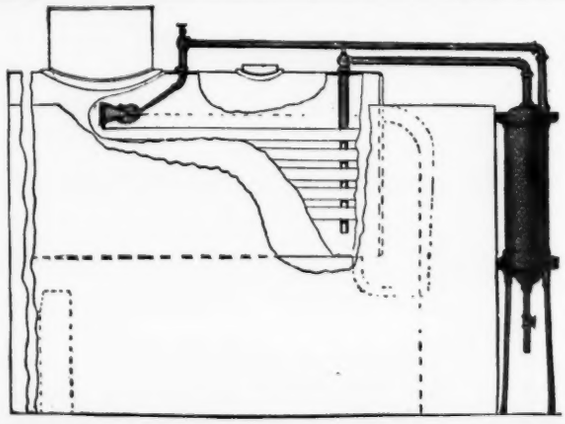
BIRD-ARCHER BOILER COMPOUNDS

prevent the formation of this scale and greasy deposit, and by so doing, not only reduce danger and repair bills, but permit the boiler to deliver the greatest possible amount of steam without waste of coal.

Guaranteed on a "NO CURE, NO PAY" basis.

WRITE FOR PRICES AND LITERATURE.

The Bird-Archer Co., 90 West St., New York.



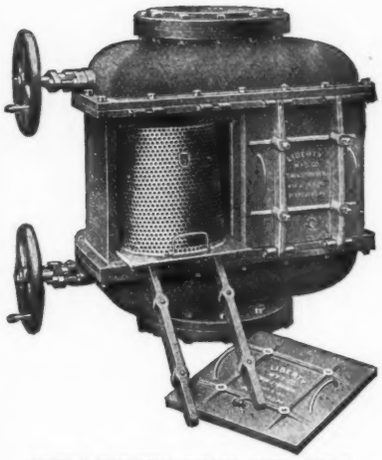
Costs Once—Cleans Continually

Just skim off the scale foaming impurities with a

Buckeye Boiler Skimmer

and you will not need compounds or tube cleaners because there will be no scale. Write today.

Buckeye Boiler Skimmer Company,
South End, Toledo, Ohio.



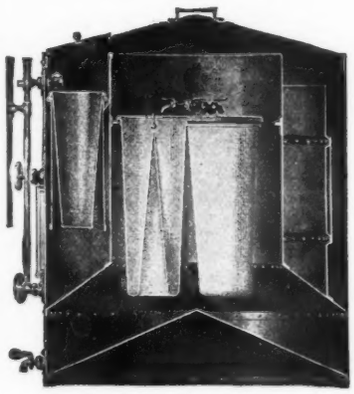
THE LIBERTY TWIN STRAINER

CLEANLINESS IS NEXT TO BIG PROFITS AND INSEPARABLE FROM THEM

The Liberty Triplets will protect your pipe lines from clogging up, keep your tubes clean and purify your oil.

These three services mean big savings in labor, fuel and oil, they also decrease depreciation losses for your entire equipment.

Our bulletins give detailed descriptions and other details.



THE LIBERTY OIL PURIFIER

WRITE

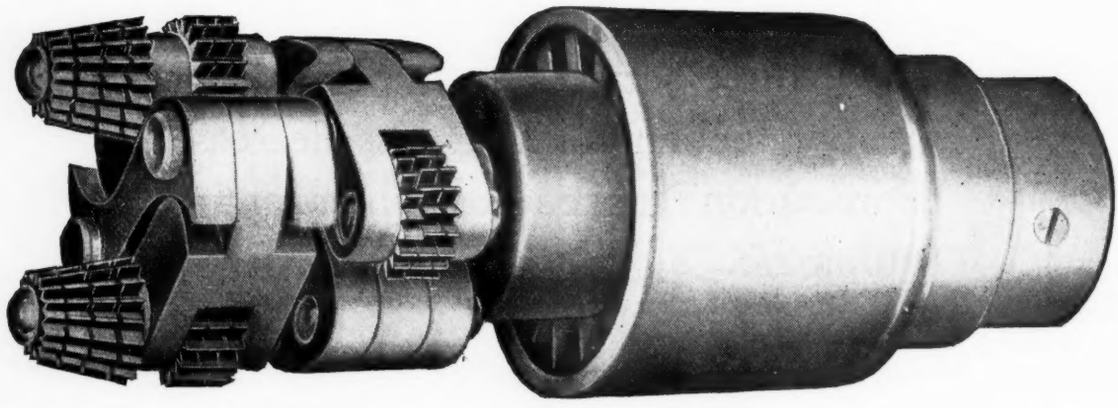
LIBERTY MANUFACTURING COMPANY

6509 SUSQUEHANNA ST.
PITTSBURG, PA.

How Much Scale Can Collect In One Day In A 200 H.P. Water Tube Boiler? 125 lbs.

Doesn't seem possible, does it? But it's so. Figure it out for yourself. A 200 H.P. boiler evaporates about 19,000 gallons of water in 24 hours. A sample of boiler water taken at Dolores, Ont., contained 48.92 grains of solid matter per gallon (MINING WORLD). 19,000 gallons of water would deposit 125 lbs. of scale-forming matter in a 24-hour run, or about 10 TONS in a year of 10-hour days. Figuring on a 10-hour day, this boiler if free from scale would burn 1100 tons of coal during the year. If scale accumulates, 200 to 350 additional tons of coal would surely be required, which at $2.50 per ton would mean a loss of from $500 to $875.00.

You can put most of this into your pocket as clear saving by cleaning the boiler regularly with the Weinland Wing Head Turbine Cleaner, which will cut this kind of scale out quicker, do it better and use less water than any other turbine put on the market. This seems a big claim but you take no chances for you can try the cleaner at our expense. There is nothing hit-or-miss or flimsy about its action, as with a "spider-leg" machine.



Remember too that the cutters are in three sets, all working in different planes at the same time. When you consider the loss and danger from scale, the Weinland Turbine would be a good investment if it didn't do half the work it is capable of doing.

Get a Weinland Turbine and try it. If it don't suit send it back. People that use them by the year find them advantageous from a financial standpoint.

WE CHEERFULLY SEND CATALOGS.

THE LAGONDA MFG. CO., Springfield, Ohio.

Makers of Weinland Mechanical Cleaners, Lagonda Reseating Machines, Automatic Cut-Off Valves and Tube Cutters.

New York Philadelphia Pittsburg Chicago San Francisco Birmingham Toledo London

[63]

A Powerful Little Device for Elevating, Conveying and Transporting Liquids—

The Garfield Ejector

Cannot be beat for raising water from deep wells, mines or pits, filling or emptying tanks, raising or transferring liquids, etc.

Note the straight pipe connections making it desirable for elevating water from deep driven or drilled wells.

Positive in Its Work and Nothing to Get Out of Order

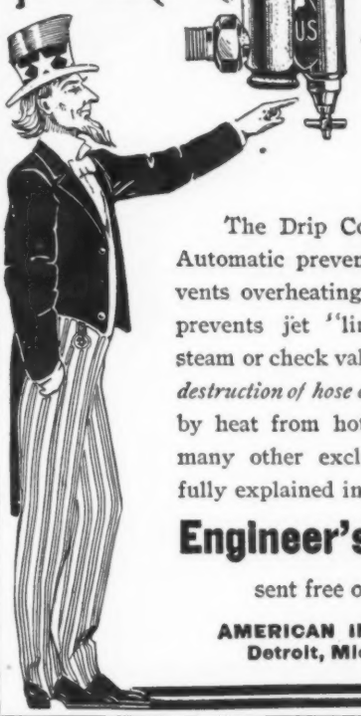
You cannot afford to be without it. Write for complete description. Large Catalog sent free.

The OHIO INJECTOR CO.,
The World's Greatest Injector Manufacturers,
WADSWORTH 110 Main St. OHIO, U. S. A.

No Freezing Here

The Drip Cock prevents it

U.S. Automatic Injector



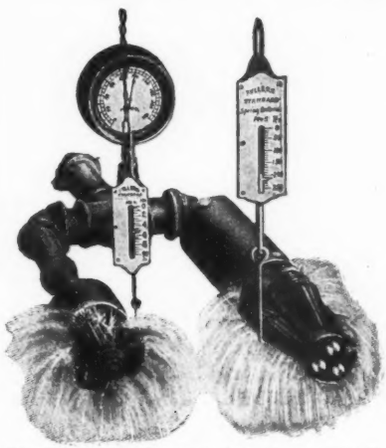
The Drip Cock of the U. S. Automatic prevents freezing; prevents overheating of suction pipe; prevents jet "liming up" when steam or check valve leaks; *prevents destruction of hose on traction engines* by heat from hot water, and has many other exclusive advantages fully explained in our

Engineer's Red Book

sent free on request.

AMERICAN INJECTOR CO.
Detroit, Mich., U. S. A.

The Pull of the "Demon"



The "Demon" on the right of photo showing over 40 times the pulling power of the turbine. Pump pressure 100 lbs. Reproduction of actual test.

It takes a mighty strong twisting force, torque or pull to clean water tubes rapidly and perfectly.

There never was a self-contained water-driven cleaner that could even approach the "DEMON" for power.

Where does the "DEMON" obtain its immense power? Here's an illustration. Press your thumb over the outlet of an open water faucet and see how soon the accumulating pressure of the water forces an opening. *This is the principle of the "DEMON."*

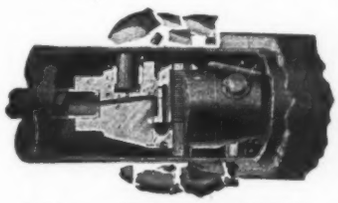
After trying the above hold your thumb a half inch or so below the opening of the faucet and you discover the pressure is slight in comparison with the previous experiment. *That is the principle employed in every turbine cleaner.*

The "DEMON" uses every ounce of pressure directly upon rotary pistons. The water *must* rotate the pistons (and the cutter head) before it can escape. With a 3" piston area and 100 lbs. water pressure it means 300 lbs. pull which reduced to practice causes a rapid crushing of all scale as it is caught under the steel roller cutters. Send for free trial proposition and don't fail to read our folder No. 54 "Demon Cleaners vs. Other Cleaners," or No. 56 on "DEMON" curved tube cleaner.

The "TORPEDO" holds the undisputed lead in the fire tube cleaner class.

Just to show you that this cleaner can save you money—lots of it and it is the best and safest cleaner you ever saw, let us send you one on free trial. If you are satisfied it will pay you 200% or more on the investment buy it, if not send it back.

Our circular No. 30 gives some interesting facts on cleaners. Want one?



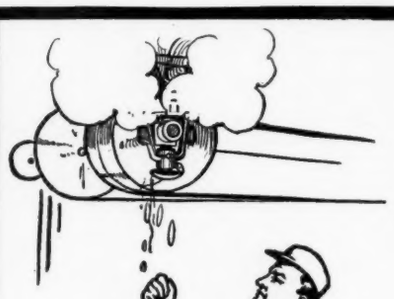
The "TORPEDO"

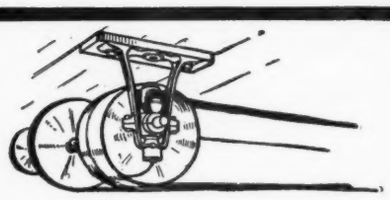
THE "TORPEDO"
Removes all scale from tubes of fire tube boilers.
Saves 11 per cent of fuel for each 1-16 inch of scale.
Prolongs life of tubes.
Saves compound.
Centers itself in tube.
Strikes same in every direction.
Stroke limited and cushioned.
Does not hammer but vibrates the tube.
Is absolutely safe and easily operated.
Has but one moving part.
Will last a lifetime.

The General Specialty Co., 887 Niagara Street, Buffalo, New York.

THERE IS ONLY ONE

ALBANY GREASE





THE SUBSTITUTE

Nothing Worse I Can Imagine

The only Genuine ALBANY GREASE has this trade mark on every package. Look and ask for it.

Send for FREE sample cup and can of "Albany Grease," giving size of tap for cup, depth of oil hole from top of cap to journal, where to be used and firm's name.

MADE ONLY BY
ADAM COOK'S SONS,
313 WEST ST., NEW YORK.

NOTHING EASIER
EZR
I SEE
IC

THE ONLY GENUINE

Detroit Improved Standard Lubricator

Some One

of our 337 different styles and sizes of sight-feed lubricators will fill any requirement you may have.

When ordering, insist on getting the genuine Detroit.

Write for a catalog of the most complete line of oiling devices for all purposes.

DETROIT LUBRICATOR COMPANY.
Detroit, U. S. A.

The "Philadelphia" Grease Cup

Automatic application of grease to the bearing without the use of spring compression. : : : :

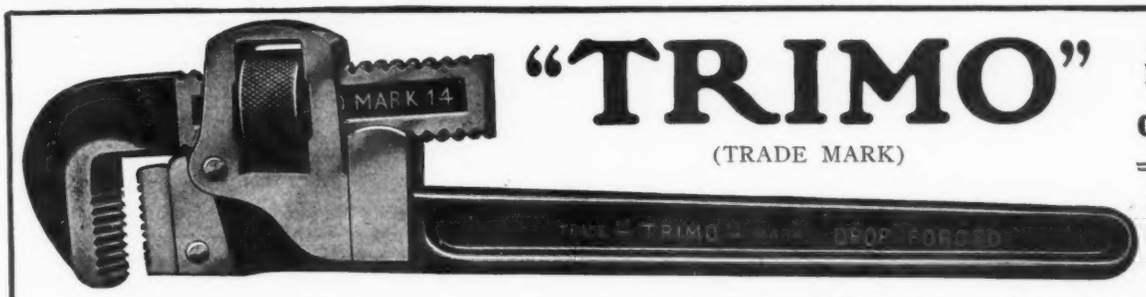
Nature Supplies the Feeding Force in the Form of Compressed Air. : : : : : : :

With many thousands of the "Philadelphia" Grease Cups in successful operation, on machinery of almost every description, we offer a system of lubrication which, for simplicity, cleanliness, economy, reliability and efficiency has no equal.

The "Philadelphia" Cup is not merely "as good as any other:" IT IS THE BEST, and we are prepared to prove our claim for actual superiority. There are more reasons for its practical success than we have room to mention here.

Write for catalogue and full information

The Philadelphia Lubricator & Manufacturing Co.
The Bourse (Exhibition Dept.), **Philadelphia, Pa.**



"TRIMO"

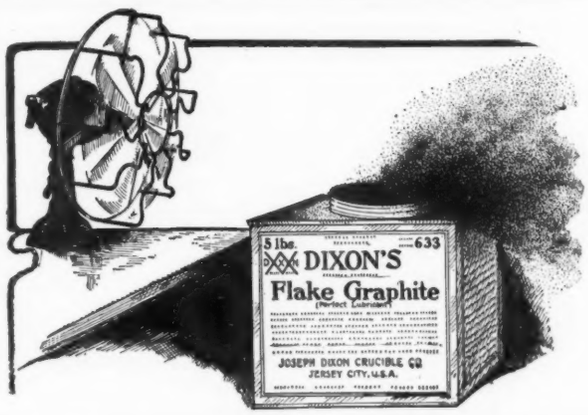
(TRADE MARK)

Our Past Record Is Your Guarantee

Send for our Catalog No. 21.

We want every user of Pipe Wrenches to give the "TRIMO" a trial. Superior in strength, working qualities, and ability to stand up under hard service. The Interchangeable Jaw in the handle adds 50% to the life of the wrench.

TRIMONT MANUFACTURING COMPANY, 55-71 Amory Street, ROXBURY, MASS.

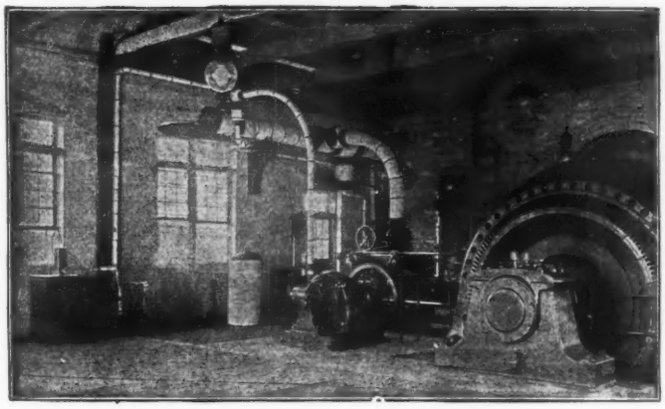


A very small quantity of Graphite will save a very large quantity of oil or grease.

Write for Free Sample 94-C

JOSEPH DIXON CRUCIBLE CO.
Jersey City, N. J.

Engine Oiling In The Modern Power Plant



Down in what most people regard as the wildest part of south central West Virginia, in the territory from which some of our finest smokeless fuels are secured, is the McKell Coal & Coke Co., Glen Jean, W. Va., operating collieries scattered at convenient points over a tract of several thousand acres. Electric power for operating these numerous scattered mines is supplied by an alternating current system of distribution from a central power plant. High-tension alternating current is transmitted from the central station to scattered substations, where it is transformed and converted into low-tension continuous current for use at the adjacent mines.

The illustration shows the first 500-k.w. alternating current generating unit in the power house, which provides space for installation of a duplicate unit. At the left may be seen the Duplex Type White Star Oil Filter and circulating pump of the White Star Continuous Oiling System here in use for lubricating all the engine bearings. Overhead, out of sight among the roof trusses, is a reservoir from which the oil is piped to feeds fitted to all the bearings on the engine. All oily drips from the various bearings are drained to a tank beneath the engine room floor, from which they are lifted automatically to the White Star filter on the engine room floor. After being thoroughly cleaned in the filter, the oil is pumped back to the overhead reservoir, ready for use again. Thus there is a constant stream of oil fed to all bearings, amounting in this case to a circulation of about 200 gallons per day. The reservoir is so arranged that any excess pumped to it would be returned through automatic valves to the filter.

By use of the White Star continuous oiling system the bearings are all supplied with a copious flood of oil, affording that generous supply which is known to be necessary to perfect lubrication, yet *absolutely without waste*, since not a drop of oil can escape from the system, except as it is actually worn out in the bearings.

We are prepared to equip power plants of any size contracting to furnish the necessary apparatus or erecting such outfits complete. Our catalog "D" treats fully on this subject. Send for it.

Pittsburgh Gage & Supply Co., Pittsburgh, Pa.

3 Pints of Oil in 28 Days

Latest **Improved**

ROCHESTER

Automatic **Lubricators**

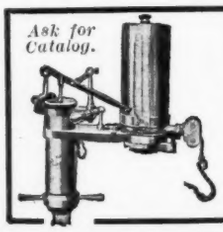
result in a great saving of oil. This is proved by the fact that a three-pint "Rochester" on a certain marine engine was only filled once on an almost continuous run of 28 days.

Our lubricators can save oil for you. Do you think it is worth while to investigate?

WRITE FOR INFORMATION.

Greene, Tweed & Co.
109 Duane Street, New York

Ask for Catalog.



A Trill On Trial

is sure to be sentenced to work for life in the plant of any fair-minded judge.

THE TRILL TRIUMPH INDICATOR

costs $50.00 less, is worth actually more, and retains its perfect efficiency longer than any other standard indicator. Get one free on trial.

Trill Indicator Co., Eagle Street, Corry, Pa.

SAGINAW MANUFACTURING CO.,

SAGINAW, MICH., U. S. A.

MANUFACTURERS OF

GILBERT WOOD SPLIT PULLEYS.

New York Branch, 88 Warren Street.
Chicago Branch, 32 South Canal Street.
Sales Agencies in all principal cities.
Cable Address, "Engrave" A. B. C. and Lieber's Code.

SAVE MONEY IN BELTING

Shultz Sable Belting saves money because it wastes less power and lasts longer than any other belting.

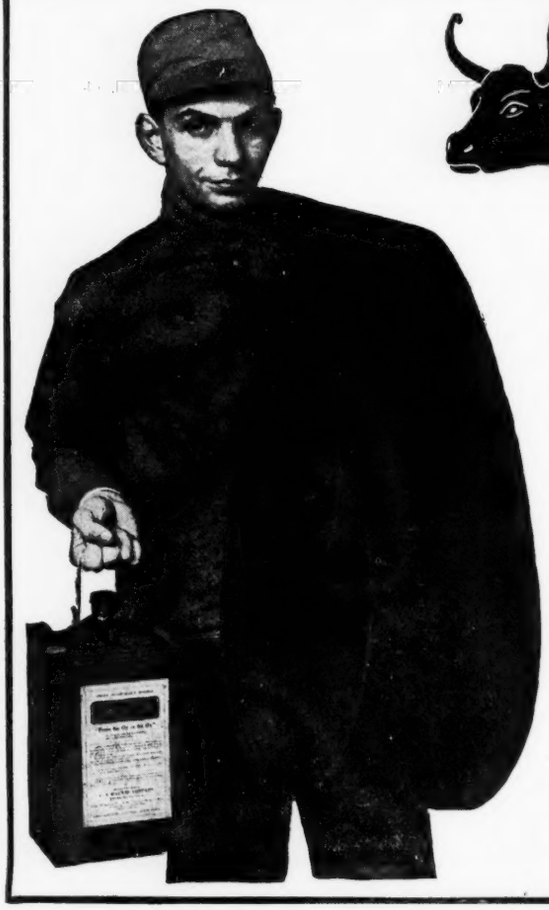
A Sable Belt does the work. It clings to the pulleys and transmits power without loss. It does not slip, does not break and costs nothing in power or time wasted or for repairs. It stands up to its work.

Our special process of tanning thoroughly tans the surface of the hides but preserves the rawhide interior. This renders the leather durable, strong and flexible.

Give Sable a trial. Send for a belt for 60 days free.

SHULTZ BELTING CO.
St. Louis, Mo.

NEW YORK, 111 Chambers St. BOSTON, 114 High St. PHILADELPHIA, 116 North 3d St.



OXOILOX

VIENNOT-PHILA

A GOOD START

is half the battle, and the very best start for *any new belt* is a thorough treatment with OXoilOX—*The Perfect Belt Dressing*. It restores to leather the strength and vitality lost in tanning. Makes belts tough, yet soft and pliable, so that they adhere closely to the pulleys, and slipping is made almost impossible.

OXoilOX is not a "*dope*," and it doesn't make belts sticky; just keeps them clean and healthy so that they can live out their full life and do a good day's work each day. You can have

A FREE SAMPLE

F. S. WALTON CO., Philadelphia, Pa.

Gentlemen: Kindly send us, free of charge, a sample can of OXOILOX the Perfect Belt Dressing.

Name.....

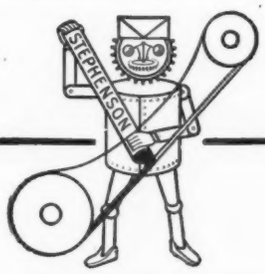
Address.....

Name of Firm.....

Number of Belts..... Average Size.....

F. S. WALTON CO., Philadelphia, Pa.

Pressers and Refiners of all grades of Neatsfoot oil



THE AFTER EFFECTS ARE PLEASANT

Don't waste good belts and lose valuable power. **STEPHENSON Bar Belt Dressings** contain no Rosin nor any other ingredients injurious to Belting. Our **RED Label** and **GREEN Label Brands** are two entirely different and distinct preparations. No **one** kind of Dressing is good for **all** Belts—you know that. **STEPHENSON Dressing** not only prevents slipping and gives full speed from slack belts, but **the after effects are pleasant**—it KEEPS those belts in good condition and greatly prolongs their life.

This means a saving in BELTING, which is an important item when figuring the year's expenses.

RED Label Brand for Leather belts;
GREEN Label for Rubber and Canvas.

Your protection against substitution is **The Man with the Cog-Wheel Face** on each Pound Stick.

Of Dealers everywhere, or

STEPHENSON MFG. CO.
ALBANY, N. Y.

Unlike All Others

The Homestead Valve seat is perfectly protected from wear both when closed and while the pressure is passing through it. BOOKLET?

Homestead Valve Mfg. Co.,
Brass Founders. **Pittsburg, Pa.**

RHOADS LEATHER BELTING

Service is the Test

J.E.Rhoads & Sons

PHILADELPHIA 12 N. THIRD ST. BOSTON NEW YORK 40 FULTON ST.

HAMBLET & HAYES CO. EASTERN AGENTS, 105-111 SUMMER ST.

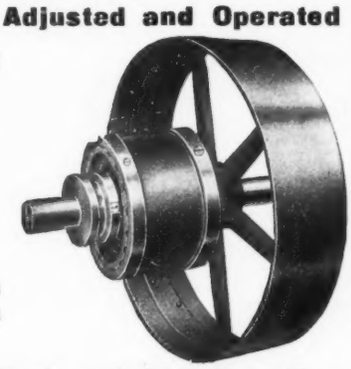
FACTORY, WILMINGTON, DEL.

Easily Installed, Adjusted and Operated

sturdily built with liberal wearing surfaces.

The AKRON FRICTION CLUTCH

is dust proof, noiseless in operation and works in an oil bath. *Write.*



The Williams Foundry & Machine Co.,
Successors to the Akron Clutch Co. **Akron, Ohio.**

We're Going to Raise Your Salary

"Yes, young man, we find that the training you have applied to your work has been so beneficial to the Company that we are going to encourage your further efforts by raising your salary."

Such scenes as these are actually taking place every day. The man who gets the raise is the **trained** man—the expert—while the untrained man plods along at the same old wages. If **you** are poorly paid and have ambition, there is a practical and definite system by which you can obtain promotion—a system that last year brought over $20,000,000 in increased salaries to the men that adopted it.

You won't have to leave home; there'll be no interruption in your work; there's no age limit; you won't have to buy books; it makes no difference what you do or where you live; lack of capital is no barrier; it makes no difference how scant your spare time may be.

If you are ambitious, mark and mail this coupon **NOW** and find out the most practical way to raise your salary.

INTERNATIONAL CORRESPONDENCE SCHOOLS
Box 979, Scranton, Pa.

Please explain without further obligation on my part, how I can qualify for a higher salary and advancement to the position before which I have marked **X**.

Electrical Engineer	Machine Designer	Sanitary Engineer
Elec.-Lighting Supt.	Mechanical Draft.	Architect
Elec.-Railway Supt.	Foreman Machinist	Architectural Draft.
Electrician	Foreman Toolmaker	Ad Writer
Telephone Engineer	Foreman Molder	Window Dresser
Civil Engineer	Foreman Blacksmith	Chemist
Bridge Engineer	Marine Engineer	Sheet-Metal Draft.
Mechanical Engineer	Hydraulic Engineer	Ornamental Design.
Stationary Engineer	Municipal Engineer	Textile Designer
Gas Engineer	R. R. Construc. Eng.	Bookkeeping
Refrigeration Eng.	Surveyor	Stenographer
Traction Engineer	Mining Engineer	Civil Service Exams.

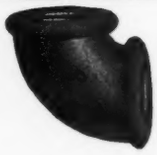
Name _____

St. and No. _____

City _____ *State* _____

You Cannot be Interested in Power Plant Equipment

Unless you are Interested in



"P" VALVES and FITTINGS

Because We Claim Them To Be The Finest Product of Their Kind.

ALWAYS SPECIFY

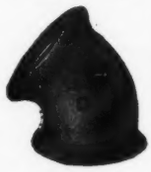
P

VALVES and FITTINGS

ALWAYS SPECIFY

P

VALVES and FITTINGS

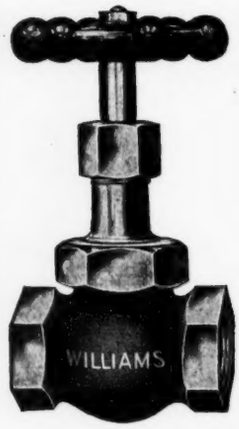


PITTSBURGH VALVE AND FITTINGS COMPANY,

General Offices and Works, BARBERTON, OHIO.

WE MANUFACTURE ALL KINDS OF VALVES AND FITTINGS. WRITE FOR CATALOGUE.

For Economy's Sake Use Williams Valves.



MODERN engineering practice has clearly demonstrated that the *regrinding valve* is the most economical, because it successfully controls steam or liquids at high pressures and temperatures without the difficulties experienced with other types of valves.

As the Williams valve is of the regrinding type, it does not require the use of extra discs or seats, should it ever become worn. That's why it's economical and that's where it will save you money.

Regrinding the disc or seat is a *simple operation*, quickly accomplished without the use of special tools or even breaking a pipe connection. When completed the valve is as good as when new, at *no extra cost*. Guaranteed for 200 pounds pressure, the Williams is seen at its best where all other valves fail.

Let your next order read—WILLIAMS.

THE D. T. WILLIAMS VALVE CO.

904-910 BROADWAY, - CINCINNATI, OHIO

2

FOSTER VALVES

Class "W."

To solve the problem of proper regulation of steam, gas or air and fundamentally to economically and safely maintain a power plant, is to install Foster Valve Specialties.

Any point as to pressure regulation that causes a doubt in your mind at any time, we will gladly take up the matter with you.

Here we want to again call your attention to our Class "W" Pressure Regulator, which maintains a constant delivery pressure, regardless of the initial boiler pressure.

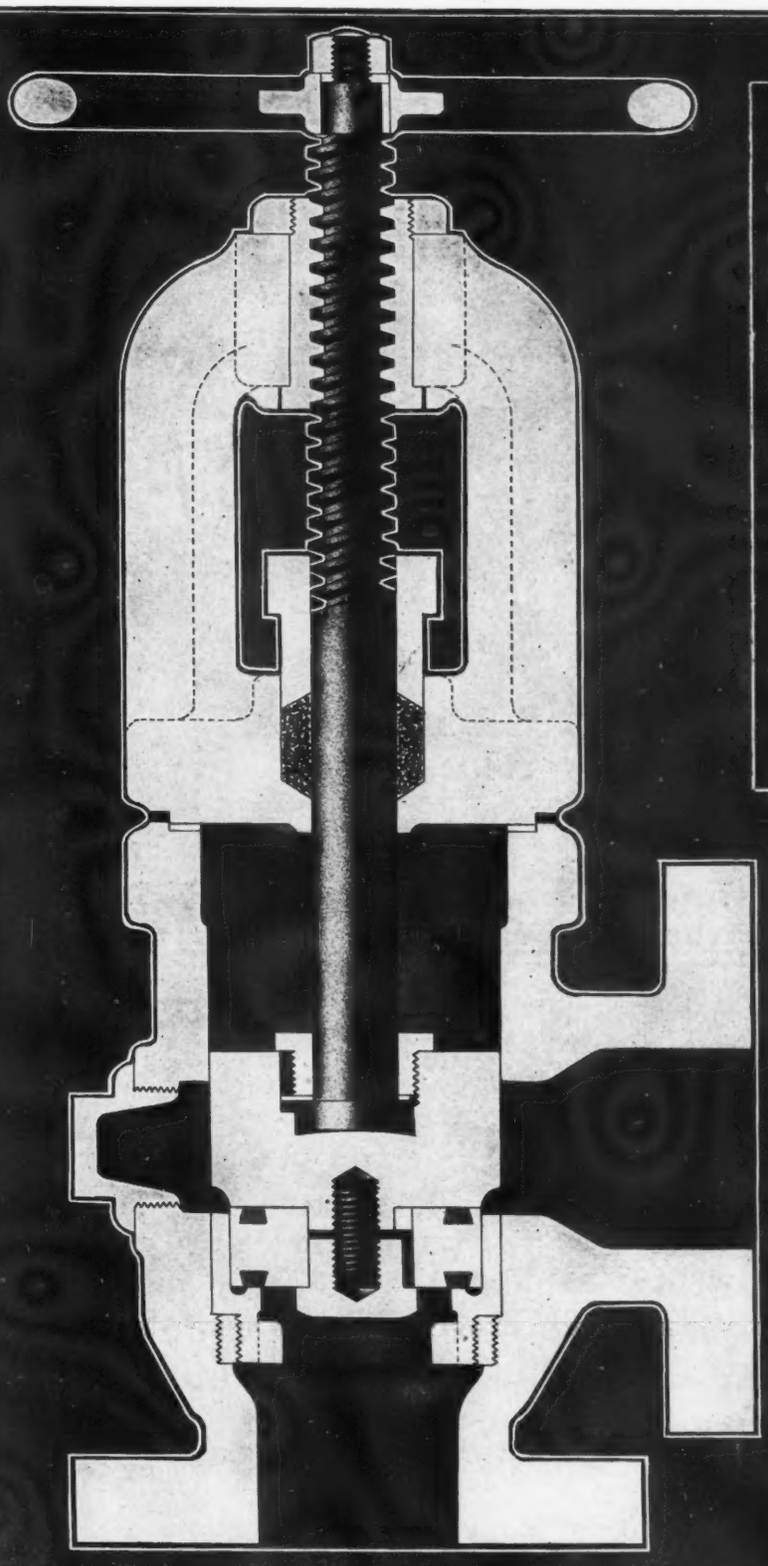
Along with this, we mention our Float Valve, Non-Return Stop Valve, Piston Actuated Pump Governor, Diaphragm Actuated Pump Governor, Etc.

Write us for our catalog.

FOSTER ENGINEERING COMPANY,

NEWARK, N. J.

Room 423, No. 40 Dearborn St., Chicago, Ill.
403 Harrison Bldg., Philadelphia, Pa.
Stock carried at
Adkins, Young & Allen Co., 50 and 52 S. Canal St., Chicago, Ill.



HERE
is a combination that
CANNOT be EQUALLED.
A Blow-off Valve with a renewable, reversible Disc and a self-cleansing, renewable Seat. It is known as the

Lunkenheimer
"DURO"
Blow-off Valve

and also the most DURABLE and PRACTICAL Blow-off Valve made.
Our catalog will tell you more about it. Write for a copy.

2

The Lunkenheimer Company

Largest Manufacturers of High Grade Engineering Specialties in the World

General Offices and Works, Cincinnati, Ohio, U.S.A.

Branches: New York, 66-68 Fulton St.; London, S.E., 35 Great Dover St.; Chicago, Lake and Dearborn Sts.

DAVIS PRESSURE REGULATORS SAVE STEAM

PRESSURE REGULATOR

Do It Automatically

If you are using live steam for heating, drying, cooking or some other purpose at a pressure lower than that carried on the boiler, let the Davis Pressure Regulator make the reduction for you automatically.

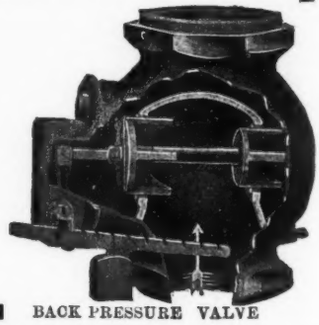
This valve can be adjusted to deliver steam at just the pressure needed and it will maintain that pressure without fluctuations no matter how much the initial boiler pressure may vary.

Reducing steam by throttling through a cracked globe or gate valve is about as satisfactory as using saw dust for fuel. You may be able to get along after a fashion, but why not do it right—automatically.

If you are running your engine non-condensing a Davis Automatic Back Pressure Valve will enable you to make use of the exhaust steam instead of letting it go to waste.

Contrast this valve with its semi balanced disc, small weight and noiseless operation without any possibility of injury to the seats, with the old style single seated valve which pounds like a trip hammer and keeps you poor buying seats for it. Is there any comparison—would you choose the single seat ?

Send for a complete catalog of Davis Valve Specialties. It is of interest to both owner and operator.



BACK PRESSURE VALVE

G. M. Davis Regulator Company,

142 Milwaukee Ave., CHICAGO.

BRANCHES—NEW YORK—123 Liberty St. BOSTON—104 High St. ST. LOUIS, 735 S. 4th St.
SAN FRANCISCO—216 California St PHILADELPHIA—56 N. 2nd St.
PITTSBURGH—1206 Park Building.

VALVES

Makes no difference what kind of a Valve you want, how you want it made or where you want it shipped, we can supply it on shortest possible notice.

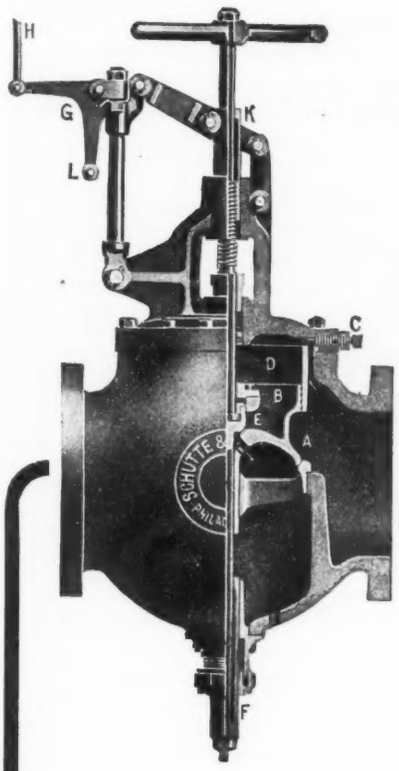
We manufacture valves and pipage equipment of every description, for all kinds of plants, Steam Separators, Tuyere Cocks, Brass Unions, Etc. Also make Pipe Bends, and do all kinds of Pipe Fitting, either assembled or ERECTED.

SEND FOR CATALOG

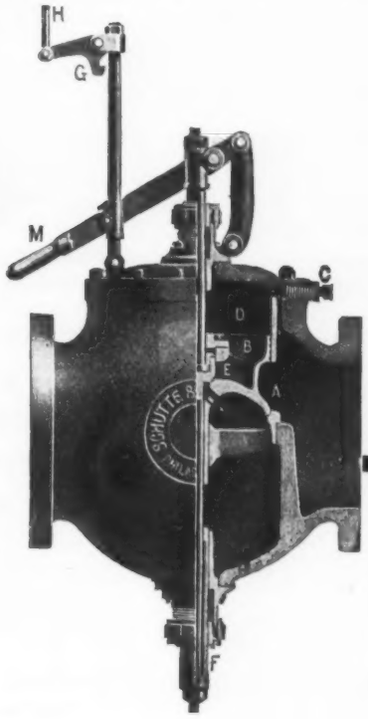
PITTSBURGH VALVE FOUNDRY & CONSTRUCTION CO.

Pittsburgh Cleveland New York Boston Birmingham, Ala.

SCHUTTE BALANCED
TRIP AND THROTTLE VALVES



ENGINE STOPS

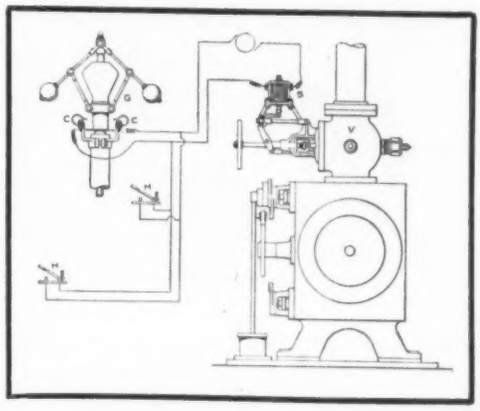


Some Users

General Electric Co.
Allis-Chalmers Co.
Westinghouse Mach. Co.
Birmingham Railway Light & Power Co., etc., etc.

Above Co's. use alone over 500

The necessity of a reliable engine stop on high speed engines of all types is now universally conceded by all engineers, as the frequent and direful results of fly-wheel explosions has taken precedent to boiler explosion, while the safe-guards and attention devoted to the latter far exceed those of the former.



Cut opposite shows the "Schutte" Balanced Trip Throttle Valve with electric solenoid "s" attached, and operated directly by engine governor "g," making contact with adjustable clips "c" when engine exceeds normal speed. It is also wired up with switches "h" placed at convenient locations for hand tripping.

Send for catalog 8-D.

SCHUTTE & KOERTING CO.

TOMPSON and TWELFTH STREETS, PHILADELPHIA

NEW YORK	BOSTON	CHICAGO	PITTSBURG	SAN FRANCISCO
50 Church Street	43 High Street	805 Security Building	Keenan Building	O. C. Goeriz & Co.

"KEWANEE" UNIONS

"M & F" Pattern. Brass-to-iron thread connection. No gaskets required, no nipples, no hammering necessary. Best for use in close places. Never rust or corrode. *Further Details?*

NATIONAL TUBE COMPANY,
PITTSBURG, PA.

DISTRICT SALES OFFICES

Atlanta Chicago Denver New Orleans New York Philadelphia Pittsburg Portland St. Louis San Francisco Salt Lake City Seattle

ARE YOU A MASON

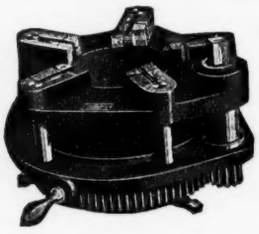
user? If not you should investigate this best of all reducing valves Locks with a key and cannot be altered without the key. Write.

THE MASON REGULATOR COMPANY
BOSTON, MASS.

Write For Our Catalog

It shows you the way to promotion and pay.

THE ASHTON VALVE CO., BOSTON, U. S. A.
NEW YORK St. John's House, London, Eng. **CHICAGO.**



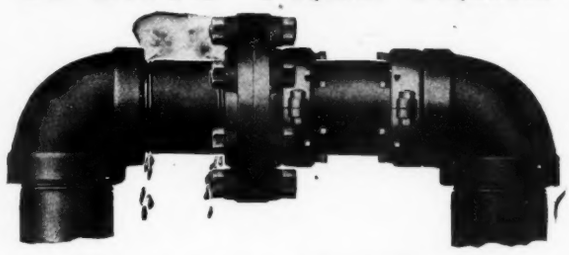
EMERGENCY WORK IN POWER PLANTS MUST BE DONE IN A HURRY.

"TOLEDO" Pipe Threading Devices

thread pipe up to 12". ONE MAN can do it quickly and *in any place, in any position.* An invaluable line of tools. Let us tell you about them.

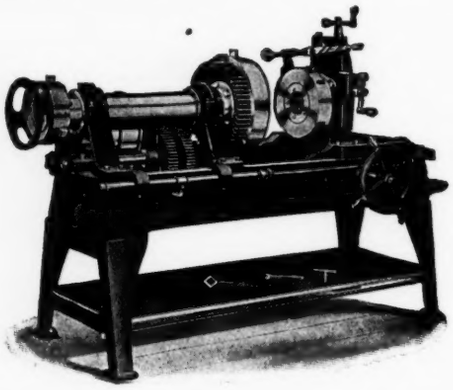
The Toledo Pipe Threading Machine Co.,
TOLEDO, OHIO.

30 DAYS' FREE TRIAL



To prove that the SIMPLEX PIPE CLAMPS will stop any leak. Write.

THE SIMPLEX ENGINEERING CO.,
316 Preston Street, PHILADELPHIA, PA.



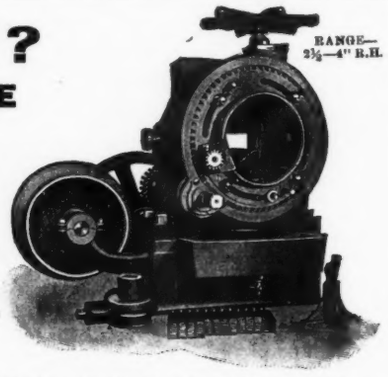
GOOD THREADS

may not be an absolute necessity if you use plenty of cement, yet there is no denying the fact that it is *better* to have *good* threads. Some may be satisfied with poor threads, but if you are a sticker for good ones, do your threading on a B. & K. PIPE MACHINE. *Yours for good threads.*

Bignall & Keeler Mfg. Co.
Edwardsville, Ill.

EASY?

IT'S A PIPE

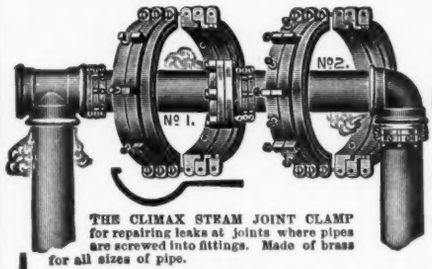


cutting and threading machine and the easiest device of the sort ever constructed.

With a Forbes Die Stock one man can do the work of four, do it better and more cheaply.

Circular?

THE CURTIS & CURTIS CO., 85 Garden St., Bridgeport, Conn.



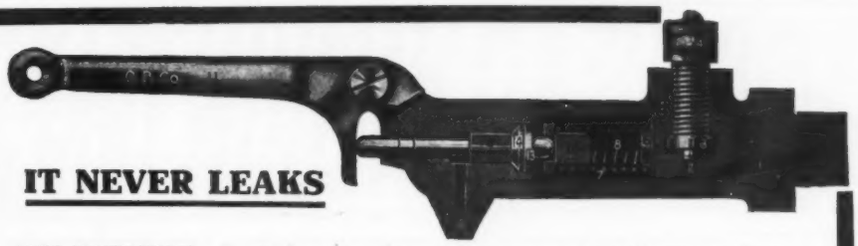
THE CLIMAX STEAM JOINT CLAMP for repairing leaks at joints where pipes are screwed into fittings. Made of brass for all sizes of pipe.

THE EMERGENCY PIPE CLAMP, for repairing splits and rust-holes. Made of malleable iron from ⅛ in. to 12 inches.

PIPE REPAIRS FOR ANY CONDITION

Send for Catalog of
STEAM SPECIALTIES
JAMES McCREA & CO.,
MANUFACTURERS,
61 West Washington Street, Chicago.

COLLIN GAUGE COCK



IT NEVER LEAKS

IS ABSOLUTELY TIGHT UNDER ANY PRESSURE. In closing, the piston "13" enters the cylinder, cutting down the velocity of the fluid through the seat "14" and preventing steam-cutting as the valve closes. A slight movement of the lever reduces velocity of discharge and prevents flashing. Made of high grade steam bronze and with or without packless, non-sticking shut-off valve.

WRITE TO-DAY FOR CATALOGUE No. P-F, describing all our steam specialties, including Water Gauges, Gate Valves and Heavy Bronze Fittings and CATALOGUE P-B describing Collin Steam Pressure Regulating Valves.

THE OHIO BRASS CO., MANSFIELD, OHIO. CHICAGO OFFICE 277 DEARBORN ST.

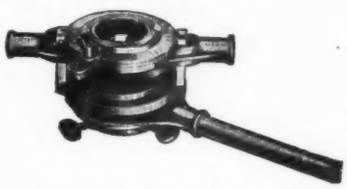
"BEAVERS" are the proper die stocks for use about factories

BECAUSE they are built on the easy working principle, enabling one man to thread any size pipe without calling for help.

Each Stock threads all sizes of pipe within its range without changing dies so you have no loose parts to carry around or get lost or misplaced.

And consider the time you save by not having to change dies.

They are a time proven success and of such practical advantage in saving time and labor as to compel their use from an economical standpoint once you realize it.

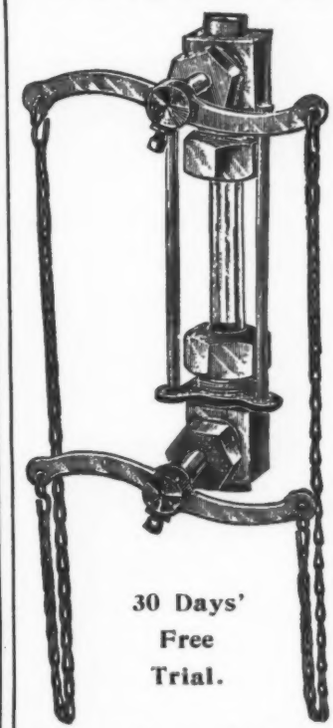


"Beaver" 1" to 2" Ratchet Stock.

Made in all sizes ¼" up.
Sold by all Jobbers subject to 10 days' trial.
We would like to send you descriptive matter.

THE BORDEN COMPANY
WARREN, O.

SCALDED ALIVE



30 Days' Free Trial.

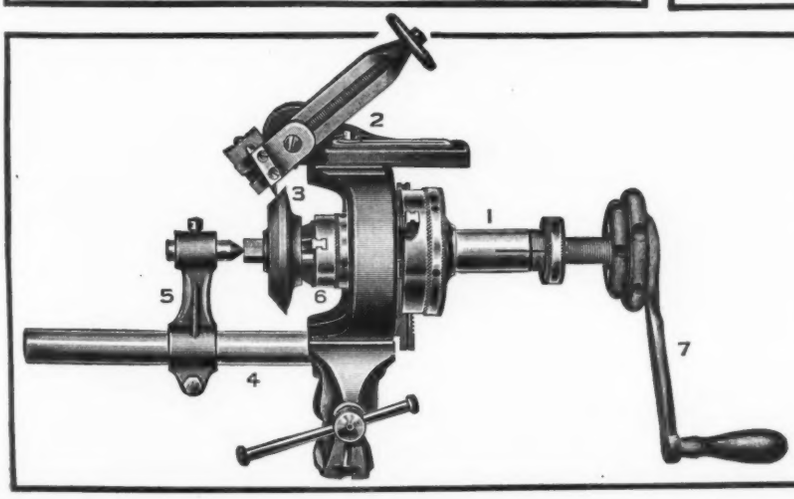
Who? Why the man who tries to shut off the live steam and scalding water when the old style water gauge glass breaks.

BE SENSIBLE

and install the **"P. B. H." Quick Closing Water Gauge.** Then, if the glass should break, you can stand out of harm's way and close it by pulling the chain.

Circular describes in full.

The Paul B. Huyette Co.,
2025 Betz Building, Philadelphia, Pa.



The most powerful fleet of warships ever gathered under the flag of the United States is equipped with Dexter Valve Machines.

The sixteen battleships and several other vessels in Admiral Sperry's fleet have a complete outfit for reseating valves ¼ to 12 inches aboard each ship.

Every navy yard and all the ships in the U. S. Navy use Dexter Valve Machines.

Send for Catalog P.

The Leavitt Machine Co.,
Orange, Mass., U. S. A.

MOREHEAD VACUUM TRAPS DRAIN

LONG EXHAUST LINES AND VACUUM OIL SEPARATORS WITHOUT BREAKING THE VACUUM.
MOREHEAD MFG CO.
1061 Grand River Ave.,
DETROIT, MICH., U.S.A.

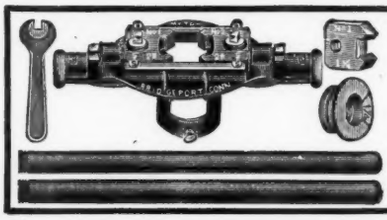
MANGANESITE PASTE

(TRADE MARK REGISTERED)

A Superior NON-POISONOUS Jointing Material of Metallic Composition; for FLANGE and SCREW-JOINTS of every description on Steam, Water, Air, Gas, Ammonia, etc. UNITES TWO METALS AS ONE. Cheaper, more efficient than red lead—no waste in its use.

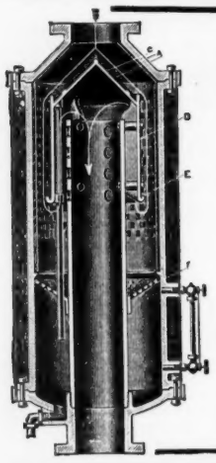
WALCH & WYETH, 87 Lake St., CHICAGO.

Manufacturers of the Erwood Straightway Swing Gate Valve. Many valuable features in one valve. Write for Catalog.



STOCKS AND DIES
PIPE MACHINES,
PIPE CUTTERS,
VISES.

Manufactured by
The Armstrong Mfg. Co.
287 Knowlton St.,
BRIDGEPORT, CONN.



SWEETS

Steam Separators deliver 99.8 dry steam and oil separators remove 99% of oil from exhaust steam. They *do* it that's all. All styles.

DIRECT SEPARATOR COMPANY,

712 S. Geddes St., Syracuse, N. Y.

A Money back Proposition

After a 30 days' trial—if you are not convinced that the Baum Separator will prove a profitable investment we will return your money and pay for returning the separator.

Send for new Catalogue and prices.

HERSHEY MACHINE & FOUNDRY CO.
MANHEIM, PA., U. S. A.

W. G. Ruggles Co., 54 High St., Boston, Mass.
R. D. Bliss, 40 Dearborn St., Chicago, Ill.

How Many Engines Have Been Wrecked

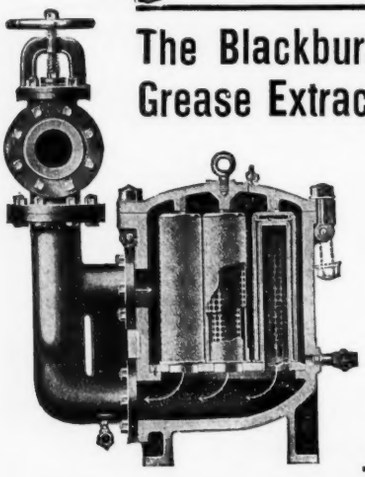
by an excess of water being carried into the cylinder? It would be interesting to know, because it is absolutely inexcusable when the use of a

Stratton Separator Assures Absolutely Dry Steam

no matter how much the boilers may foam, or how long a pipe line is exposed to cause condensation. If the cut doesn't explain it our catalog will.

GOUBERT MANUFACTURING COMPANY
No. 90 West Street, New York City, N. Y.

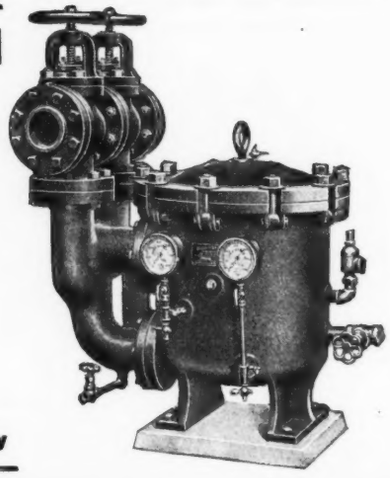
The Blackburn-Smith Feed Water Filter and Grease Extractor in the Feed Line



is the best possible defense against getting oil, grease, or mechanically suspended particles into the boiler. No line separator removes all oil from the exhaust and open heaters often let oil get to the boilers. Where such apparatus is used the Blackburn-Smith Filter offers a final and effective protection by double filtering every drop of water through separated Terry cloths.

Write for booklet "Feed Water Filtration"

James Beggs & Co.,
106 Liberty St., New York City



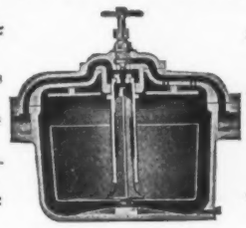
Kitts Specialties For Power Users

PUMP GOVERNORS
REDUCING VALVES
STEAM TRAPS
SAFETY FEED WATER REGULATORS
FAN ENGINE REGULATORS
LOW WATER ALARMS
SAFETY WATER COLUMNS
DAMPER REGULATORS
LOW PRESSURE BOILER FEEDERS
VACUUM PRESSURE REDUCING VALVES

Kitts Manufacturing Co.,
Oswego, N. Y.

Nason Manufacturing Company's STEAM TRAPS

SPECIFY:
Class B for pressures less than 20 lbs.
Class C for pressures 20 to 70 lbs.
"Sidelue" for pressures 40 to 150 lbs.



THE TRAP THAT ALWAYS "FILLS THE BILL"

Nason Manufacturing Company's "Immersed Valve" Boiler Feeder

FOR LOW PRESSURE STEAM BOILERS

As a safeguard against the destruction of boilers through careless handling they are a necessary adjunct. Special Catalog.

NASON MANUFACTURING COMPANY
71 FULTON STREET, NEW YORK

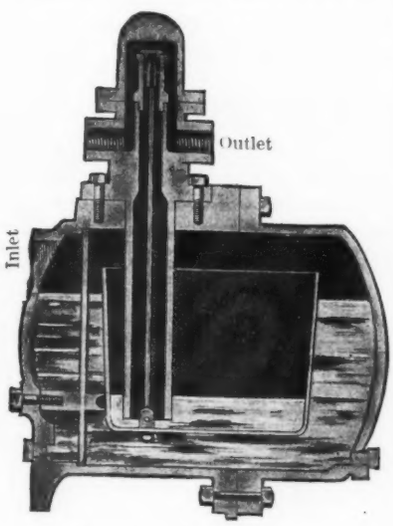
4/S STEAM TRAPS

Our
CATALOG "A"
Describes Them.
MAY WE SEND IT?

Nothing to adjust.

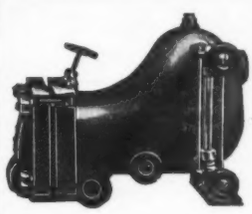
Starts right in to work and keeps at it till it's worn out.

Can you ask more?



THE STRONG, CARLISLE & HAMMOND CO.
342 Frankfort Ave., CLEVELAND, O.

54 No. 6th St., Philadelphia. 88 Broad St., Boston. 261 Centre St., New York.



McDANIEL STEAM TRAPS

are especially adapted for draining steam separators and high pressure mains. Also good for steam heating. All working parts are attached to the bonnet, and are removable with it. Valve outlets are large, to give rapid discharges of condensation.

Watson Steam Pump Governor

should be used on all steam pumps where a fixed discharge pressure is desired.

The construction permits of easy access to the stuffing box for removing packing, and the spring can be adjusted or entirely removed without interfering with any other part of the valve. Any practical man will readily see its advantages.

All our goods are made in our own factory and tested before shipping. We guarantee them to give perfect satisfaction. Established 1878.

Send for Catalogue.

Watson & McDaniel Co.,
148 North 7th Street, Philadelphia, Pa.

ON GUARD!

The **GEIPEL STEAM TRAP,** being automatic, is ever on the alert, hence no steam can escape.

Made In Seven Sizes and for All Pressures.

WRITE FOR CIRCULARS.

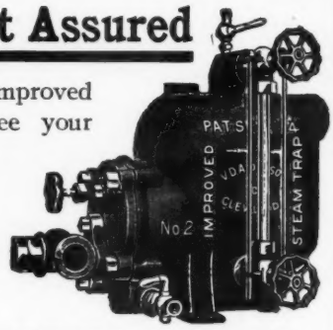
JOHN PLATT & COMPANY

97 Cedar Street **NEW YORK**

You Can Rest Assured

that the Anderson Improved Steam Trap will free your steam system of condensation troubles and that without loss of steam.

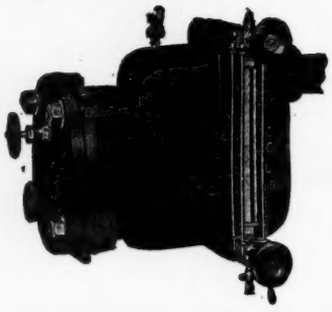
WRITE.



THE V. D. ANDERSON CO.,

1935 West 96th Street, **CLEVELAND, OHIO**

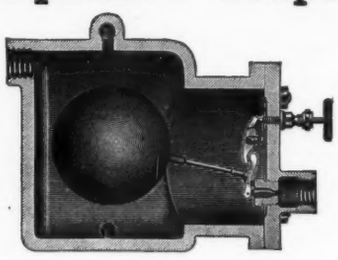
All The Best Features Of The Most Expensive Traps



combined with simplicity of construction and accessibility make the

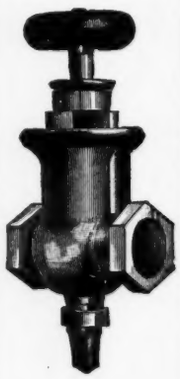
RELIANCE STEAM TRAPS

splendidly efficient yet inexpensive to buy and maintain. Its entire internal mechanism can be removed by simply removing the cap.



WRITE

THE RELIANCE GAUGE COLUMN CO., 75 East Prospect St., Cleveland, O.



LOOK FOR "CURTIS"
On Your Engineering Specialties

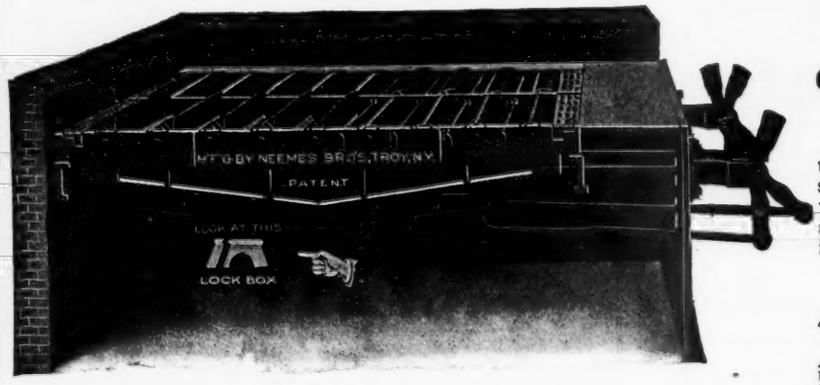
It is your protection against poor goods and poor service—see that you get it.

Balanced Steam Trap
Return Steam Trap
Expansion Trap
Separator
Damper Regulator
Temperature Regulator
Improved Pressure Regulator
Tank Governor and Pump

These and other specialties described in our catalogue. Write for a copy.

JULIAN D'ESTE COMPANY

24 CANAL STREET, **BOSTON, MASS.**



NEEMES BROS.

IMPROVED

Clinker Cutting, Shaking and Dumping Grate

unlike all other grates will cut from both sides of the shaker alike. Makes more steam with cheaper fuel and less of it. A slight agitation shakes out the ashes or a full opening dumps everything into the ashpit. *Write.*

NEEMES BROS.,

41-49 Adams St., TROY, NEW YORK

C. W. VAN BLARCOM, Room 533, Terminal Bldg., 30 Church St., Agent for New York City and vicinity BABCOCK & WILCOX, Ltd., Montreal, Canada, Sole makers for Canada BURKE ENGINEERING CO., 311 Industrial Bldg., Providence, R. I., Sole Agents for the New England States.

CONTRACTORS.
CENTRAL STATION HEATING.
Write for valuable information.
AMERICAN DISTRICT STEAM CO.,
Lockport, N. Y. Toronto, Can. Chicago.

Wing's Turbine Blower
FOR FORCED DRAFT
Most Efficient Most Compact Catalog?
L. J. WING MFG. CO., 90 West Street, NEW YORK

"SIROCCO"
TRADE MARK
FANS AND BLOWERS
BUILT ON THE TURBINE PRINCIPLE
SIROCCO ENGINEERING CO., 138 Cedar Street, New York

MARTIN GRATES
Martin Anti-Friction Rocking Grates will burn slack coal and get the same steam results as ordinary grates do with best lump coal. Catalog tells why.
MARTIN GRATE COMPANY, 281 Dearborn Street, CHICAGO.

ANY TYPE OF BOILER
The Murphy Automatic Smokeless Furnace
burns slack and other low cost fuels with unexcelled economy and absolute smokelessness. Strictly automatic in feeding and distribution of coal and the removal of the ash. Send for a complete description.
MURPHY IRON WORKS, 5 Walker St., DETROIT, MICH.
UNITS OF ANY SIZE

PREVENT SMOKE
Write to us for descriptive matter relating to a device that is mechanically correct, simple in construction, absolutely automatic, and its effectiveness in preventing smoke from Bituminous coal under any and all conditions has been fully demonstrated.
CLIMAX SMOKE PREVENTER COMPANY
205 Equitable Building, Boston, Mass.

Glazed Fire Clay Tile Inside And Out
"CHIMNEYS"
WIEDERHOLDT CONSTRUCTION CO.
American Trust Bldg., Chicago, Ill.

ELEPHANT BRAND
DELTA
REG. U.S. PAT. OFF.
THE PHOSPHOR BRONZE SMELTING CO., Limited.
2200 WASHINGTON AVENUE, PHILADELPHIA, PA.
ELEPHANT BRAND "Phosphor Bronze"
INGOTS, CASTINGS, WIRE, RODS, SHEETS, Etc.
— DELTA METAL —
CASTINGS, STAMPINGS AND FORGINGS
ORIGINAL AND SOLE MAKERS IN THE U. S.

JEFFREY
COAL AND ASH HANDLING MACHINERY.

For Power House Equipment, Plans and Estimates free with Catalogs on Elevating, Conveying, Power-transmitting.
The Jeffrey Mfg. Co., Columbus, Ohio, U. S. A.
New York Chicago Boston Pittsburg St. Louis Denver

We can elevate or convey your COAL a distance of 100 feet for less than ONE CENT A TON
in quantities of ONE TON A MINUTE or more.
Catalog Free.
THE C. O. BARTLETT & SNOW COMPANY,
Cleveland, Ohio.

MECHANICAL DRAFT BEATS A CHIMNEY.
B. F. STURTEVANT CO., Boston, Mass.
General Office and Works, Hyde Park, Mass.
New York Philadelphia Chicago Cincinnati London

The Monarch Boiler Arch
Easy to set, remove or reset.
Booklet on request.
MAYVILLE SPECIALTY MFG. COMPANY,
Mayville, Wisconsin.

CO_2 CO_2 CO_2
C-O-Two Tile
FIRE ARCHES
Any Rise, Any Span,
Air Baffle Mixing System
produces
RESULTS
C-O-TWO FURNACE COMPANY, Syracuse, N. Y.

GREEN TRAVELING CHAIN GRATES
AUTOMATIC SELF CLEANING SMOKELESS
GREEN ENGINEERING CO.
COMMERCIAL NATIONAL BANK BLDG., CHICAGO.
GENERAL FOUNDY WORK A SPECIALTY

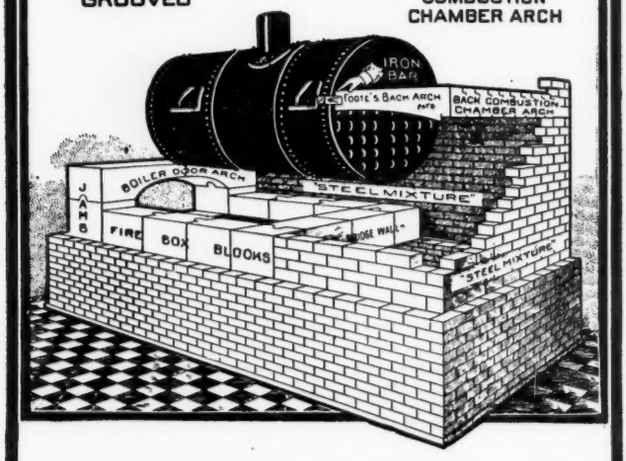
Over 7500 Hammel Oil Burners
In use under Stationary Boilers, Locomotives, Kilns, Etc.
Write for Circular of Hammel Patent Furnace for Water-Tube Boilers
HAMMEL OIL BURNER CO.
609 North Main Street, LOS ANGELES, CAL.

"STEEL MIXTURE"

BOILER DOOR ARCHES AND FIRE BOX BLOCKS

TONGUED AND GROOVED

PATENT BACK COMBUSTION CHAMBER ARCH



FIRE BOX BLOCKS

In an externally fired boiler the fire-box lining should be made as tight and durable as possible. "STEEL MIXTURE" Fire Box Blocks are distinctly advantageous for this purpose.

Their joints are tongued and grooved to prevent leakage of air and their size as compared with ordinary brick lining reduces the number of joints by 75%.

They present a smooth, practically unbroken surface to the action of the fire and there are no jagged spots or loose bricks to catch clinkers or weaken the whole.

Write for Dimension Booklet.

MANUFACTURED BY

McLEOD & HENRY CO.

TROY, N.Y., U.S.A.

BRANCH OFFICE, 1402 BROADWAY, NEW YORK CITY.

Let The Otis Help

you to pay your coal bills and protect your boiler from sudden variations of temperature.

The Otis Tubular Feed Water Heater

is the only one built on lines which make cleaning rarely ever necessary by reason of the angle at which the lower tube plate is set.

WRITE

The Stewart Heater Co.,

45 E. Delavan Ave., Buffalo, N. Y., U. S. A.

The Cost of Smoking

Chimneys equals fully 15% of your total fuel bills.

The Wilkinson Automatic Stoker and Smoke Preventer will save all this cost and a lot more beside.

WRITE FOR A CATALOG.

The Wilkinson Manufacturing Co.,

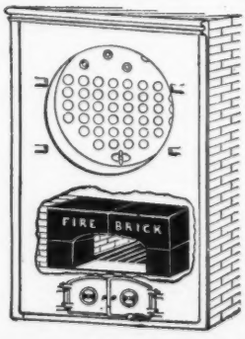
Bridgeport, Montgomery County, Pa.

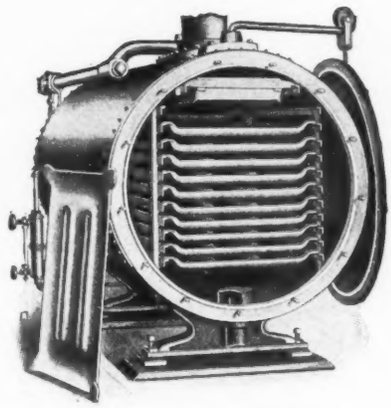
HEAT PROOF

The heat resistance of our fire brick is wonderful. We fit every type of boiler setting.

Write for catalog and prices.

Presbrey Fire Brick Works,
Taunton, Mass.





CLASS "F" CAST IRON CONSTRUCTION

HOPPES

Exhaust Steam Feed-Water Heaters and Purifiers

Are Built on Correct Principles

The raw water is brought in *direct contact* with the exhaust steam as it flows in *thin films* along the under sides of the pans, and as the pans afford a most extensive heating surface, it is heated to the *highest possible temperature* obtainable from exhaust steam.

The peculiar *trough shape* of the pans affords an excellent settling chamber for solids in suspension, while those thrown out of solution by the heat from the exhaust are caught and retained by capillary attraction on the under surface of the pans. The pans all rest on steel angle ways and are *easily removable* for cleaning.

Hoppes Heaters contain no perforated plates to give the "sprinkling can" effect and soon become clogged and inefficient, but the water flows smoothly and evenly over the heating surface and the heating and purifying action is in no way retarded by the deposit of scale on the pans.

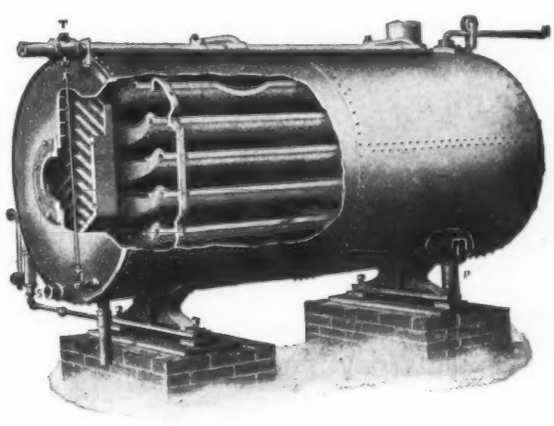
Every Hoppes Heater is provided with an efficient Oil Extractor and Automatic Feed-Water Regulating Valve and all fittings necessary to make it complete and ready for piping. They are built in either Steel or Cast Iron construction to suit conditions and requirements, and with or without water storage capacity as may be desired. GUARANTEED in every respect.

We also Manufacture

Live Steam Feed-Water Purifiers
Steam Separators Oil Eliminators
Cast Iron Exhaust Heads

WRITE FOR CATALOG

HOPPES MFG. CO.
19 Larch St., SPRINGFIELD, O.



STANDARD STEEL CONSTRUCTION

Harrisburg Feed Water Heaters

Of Pure Seamless Copper Coils. Guaranteed to be the most effective, most durable and cheapest heater manufactured.

Please write for Descriptive Catalog.

COPPER, IRON AND BRASS PIPE COILS AND BENDS OF ANY DESIRED SHAPE

Manufactured by

The Harrisburg Pipe & Pipe Bending Co.

950 HERR STREET, HARRISBURG, PA.

Manufacturers of HIGH GRADE

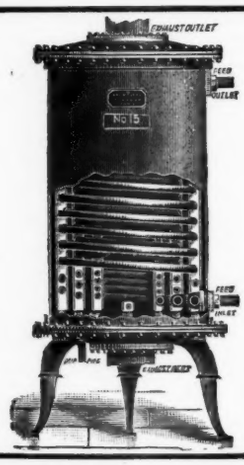
Wrought Iron

PIPE

BLACK AND GALVANIZED

No Freak Features But Every Worthy Improvement

known to feed-water heater construction and a few exclusive advantages of its own.



More National Feed Water Heaters have been sold in the past 25 years than any other make.

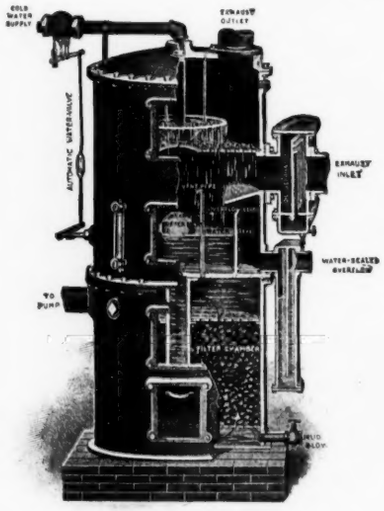
The National Pipe Bending Company

175 LLOYD STREET, NEW HAVEN, CONN.

120 Liberty Street New York

54 High Street Boston, Mass.

THE WHITLOCK OPEN EXHAUST Feed Water Heater and Purifier



Perfect Oil Separation. Easily Cleaned. The Highest Possible Temperature in the Feed Water.

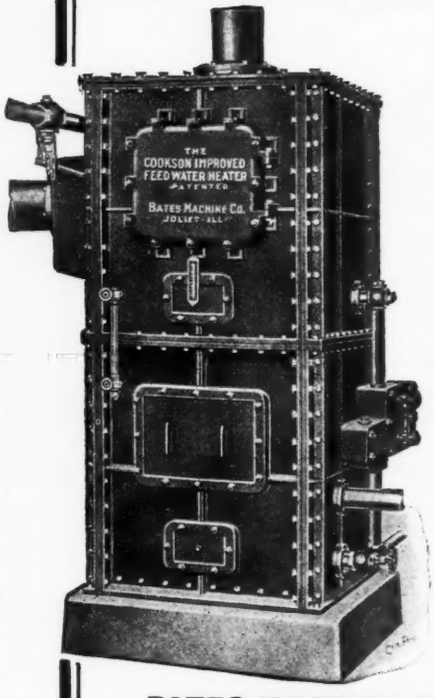
Manufactured by

THE WHITLOCK COAL PIPE COMPANY

HARTFORD, CONN.

New York Office—Singer Building, 85 Liberty Street.

COOKSON STANDARD ALL CAST IRON FEED WATER HEATERS



Highest Temperature and Positive Purification of feed water.

Perfect Separation and Removal of Oil.

Automatic Control of Cold Water Supply.

Dry Steam for Heating Purposes.

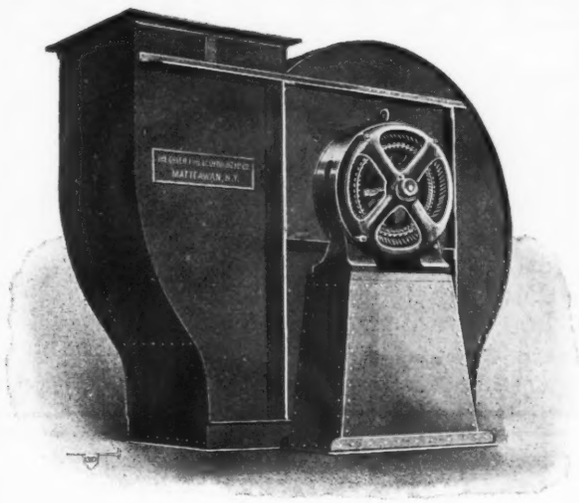
Finest Grade Special Fittings.

Lime Catching Pans. Especially Adapted for use with Heating Systems, Dryers, Etc.

Write for our new Heater Catalog.

BATES MACHINE COMPANY

Sole Manufacturers **Joliet, Illinois**



We Build Fans
FOR
Every Useful Purpose

We have built the largest MECHANICAL DRAFT fans ever constructed with overhung wheels. We have built great numbers of FANS FOR HEATING AND VENTILATING, many of them of special design and construction to suit space limitations or other special requirements.

We have built FANS FOR DRYING MATERIALS, such as BRICK AND TILE, PAPER, LUMBER, CLOTHES in laundries, BAKING POWDER, GLUE, MALT, ETC., ETC.

We have built fans for GAS PLANTS, for MINES, for EXHAUSTING SHAVINGS, BARK, SAWDUST, STRAW, WOOL, EMERY DUST, ETC., from wood and iron working and textile machinery.

All of our fans are specially heavy and substantial. We use ¼-inch plates where others use 3-16 inch plates. We adjust every wheel, not only for static balance, but also for running balance. Our fans have ring-oiled adjustable bearings and we provide special wheels to meet special requirements.

Besides building the fan we do the engineering work necessary for its proper installation and operation. We have had experience in a great variety of plants, and in our engineering department have on file engineering data and plans which are based upon what has been done and tried out before. This information goes along with the apparatus, as it is to our interest that the purchaser receive satisfactory service.

Our experience in special lines, such as mechanical draft, heating and ventilating, drying brick and tile, drying materials in factories, in installing planing mill exhausters, drying in breweries, gas making, drying in laundries and textile establishments, etc., has been partially set forth in special booklets, any one of which we would be pleased to send upon request. Also ask for our General Fan Catalog "P104," which contains valuable engineering tables and information.

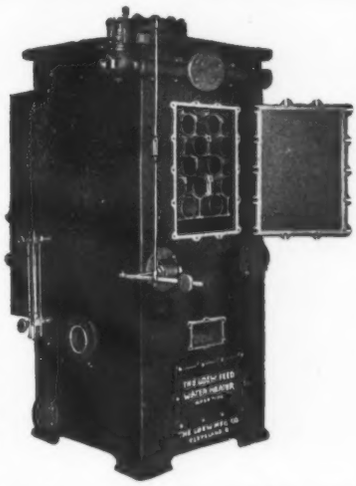
The Green Fuel Economizer Co.
Matteawan, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

Engineers; Builders of Green's Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines.

152

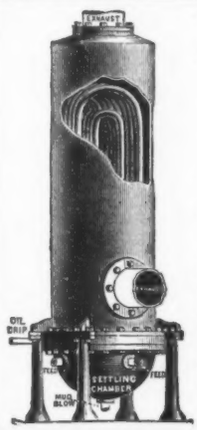
The LOEW
Feed Water Heater



and Purifier does four things which make it invaluable to the wide-awake power user.

1—extracts the oil from the exhaust steam; 2—saves and utilizes the condensed exhaust steam; 3—removes scale-forming impurities and thoroughly purifies the feed water; 4—delivers the water to the boiler at a temperature of within 2 to 5 degrees of that of the exhaust steam. Write for complete catalog.

The Loew Manufacturing Co.
Cleveland, Ohio



If You Cannot Come

to see the Patterson-Berryman Feed Water Heater, we will send one to see you. Try it 60 days and send it back or pay for it as you see fit.

Write for a Catalog.

Frank L. Patterson & Co.,
26 Cortlandt St., New York, U. S. A.

The Reilly Multicoil Heater

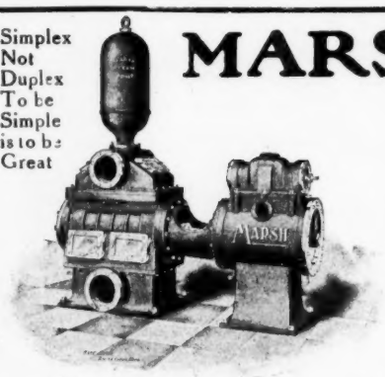
Used by the U. S. Government because it is the lightest, most efficient, and the best designed feed water heater.

It costs no more than less efficient types. It gives better and longer service than the most expensive. We recommend using a thermometer to prove our guarantees.

THE GRISCOM-SPENCER CO.
90 West Street, New York

STEAM BOILERS — ENGINES — TANKS
THE REILLY GREASE EXTRACTOR AND FEED WATER FILTER

Simplex Not Duplex To be Simple is to be Great



MARSH BOILER FEEDERS

are designed for handling hot as well as cold water. They are *at regular prices* fitted with bronze Piston Rods, bronze Water Cylinder Liners held in place by Studs, bronze Valve Seats, Stems, Nuts and glands. THE BEST OF MATERIAL AND THE BEST OF WORKMANSHIP ONLY GO INTO **MARSH PUMPS.**

Write for Catalog 17-G.

American Steam Pump Co., Battle Creek, Mich.

The Highest Practicable Vacuum

The **Baragwanath Syphon Condenser** will secure and maintain a vacuum ranging from 24 to 26 inches on engine service and as high as 28 on vacuum kettles evaporators and stills.

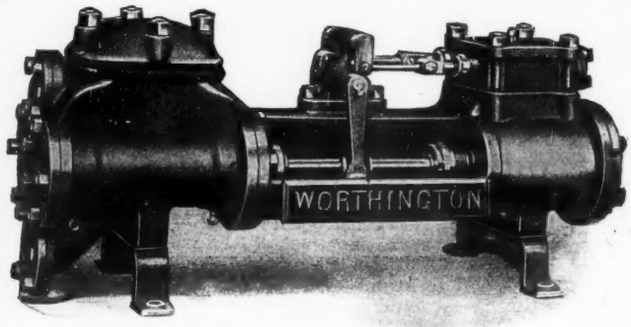
WRITE.

Wm. Baragwanath & Son,

54 West Division St., Chicago, Ill., U. S. A.

Thos. B. Whitted, Piedmond Bldg., Charlotte, N. C, Southeastern Manager.

Boiler Feed Pumps



If the Name of

WORTHINGTON

is on Your Pump it Means

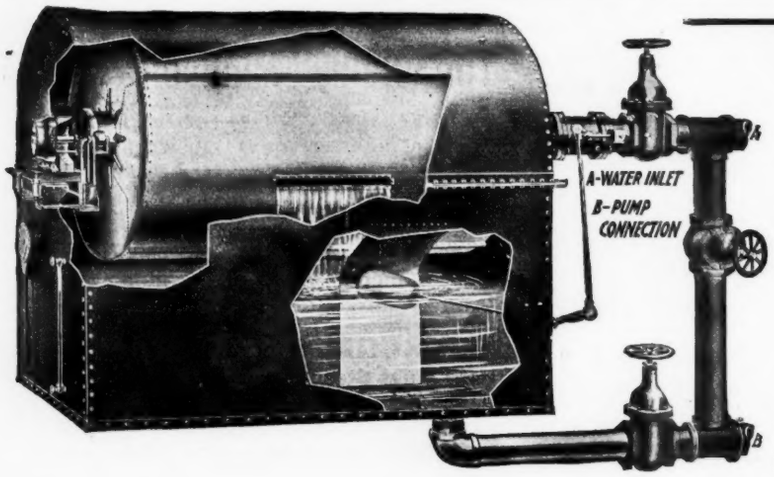
BEST WORKMANSHIP
MATERIAL
DESIGN
SATISFACTION

Write for Bulletin W. 117.

HENRY R. WORTHINGTON

115 Broadway, NEW YORK.

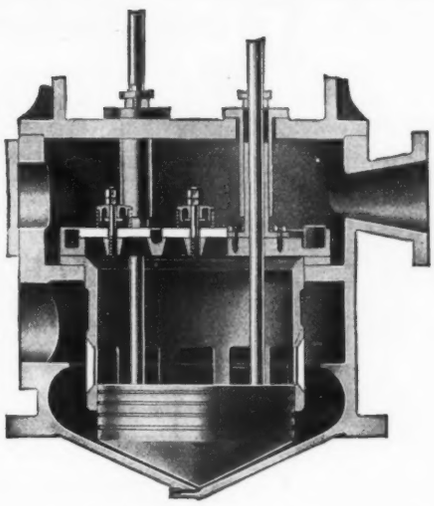
Works, Harrison, N. J.



What Are Your Boilers Doing?

Are you getting the best economy?
Is your coal best fitted for your purpose?
Can You Tell Your Evaporation?
A
DETROIT METER
Will Give You a Continuous Record of Your Boiler Feed Water
Built in all sizes for all requirements of power plants, heating companies and for measuring any liquid.

CENTRAL STATION STEAM COMPANY
Detroit, Mich., U. S. A.
SEND FOR CATALOG.



Ever Have Trouble Finding The Leaky Valve ?

Not if it was a WHEELER-EDWARDS PATENT AIR PUMP. In the first place the Wheeler-Edwards pump has very few valves, no foot-valves to keep the air and water out of the cylinder when they ought to come in, and no bucket valves to be slammed up and down by each stroke of the piston. The only valves are the head valves and these are so located that you can inspect them by removing a hand hole plate, even when the pump is running.

The Wheeler-Edwards valves are in so favorable a position that there is little probability of one of them leaking, but if one should leak, it is easy to find which one it is. The valve seat is constructed with ribs between the valves and a rib around the outer edge, so that each valve stands in its own pool of water, separate from the others. To find which valve is leaking, turn the pump over so that the piston is part way down. This will put atmospheric pressure on the water standing in the valves. Then notice where the water leaks away and you will have the valve that needs attention.

The Wheeler-Edwards Air Pumps give as high or higher vacuums than dry vacuum pumps combined with hot-well pumps and air coolers, and they cost much less in the first place and for maintenance and operation.

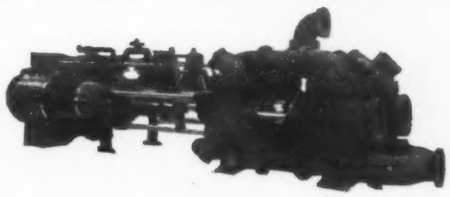
Send for a copy of our Treatise, "103-P," which not only describes the pumps, but contains other information of interests to users of vacuum machinery.

WHEELER
CONDENSER & ENGINEERING CO.
CARTERET, NEW JERSEY.

New York, Cincinnati, Chicago, Denver, Boston, Pittsburg, St. Louis, San Francisco, Atlanta, Houston, St. Paul.

(Builders of Wheeler Surface, Wet and Barometric Condensers, Wheeler-Volz Combined Surface Condensers and Feed Water Heater, Wheeler Feed Water Heaters, Barnard-Wheeler Cooling Towers, Wheeler-Edwards Air Pumps, Wheeler Centrifugal Pumps, Wheeler Rotative Dry Vacuum Pumps and Wheeler Multiple Effect and Evaporating Machinery). 14

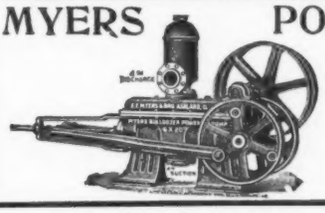
Warren Steam Pump Co.
Warren, Mass.
PUMPS FOR ALL REQUIREMENTS.



Piston—Plunger—Hydraulic—Deep Well—Power.

Air Pumps and Jet Condensers, Combined Air and Circulating, and Marine. *Catalog.*

MYERS POWER PUMPS



Adapted especially for gas engines, motor and belt powers, in harmony with present requirements. Catalog sent on request.

F. E. Myers & Bro.,
Ashland, Ohio, U. S. A.

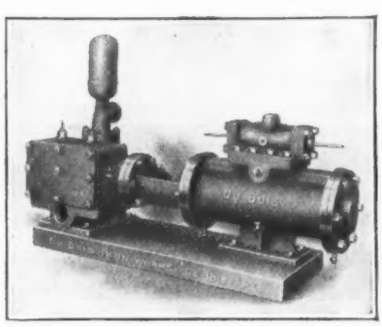
No Unequal Expansion

or contraction results from feeding properly heated water to the boiler. **Eclipse Purifiers** deliver the water to the boiler at almost boiler temperature.

The Eclipse Feed Water Heater & Purifier Co.,
Oshkosh, Wisconsin.

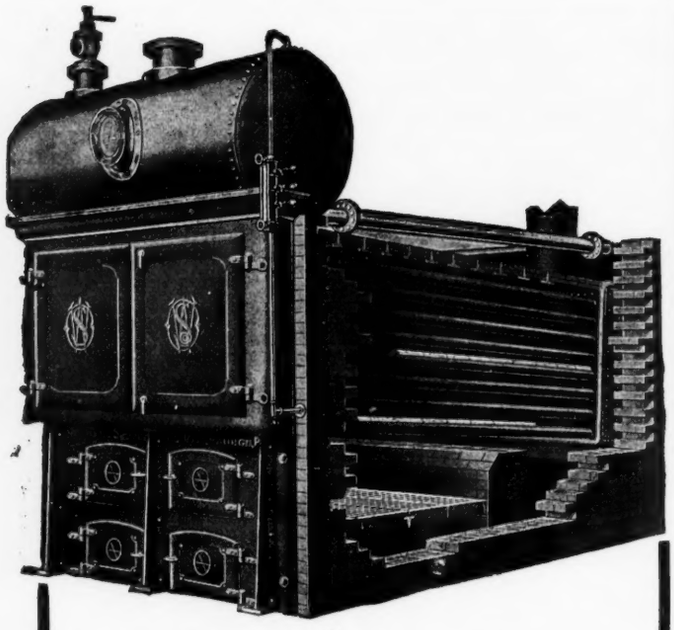
DUBOIS PUMPS

BUT ONE VALVE



and that perfectly balanced and entirely free from friction. This feature makes the Du Bois Pump superior to all others in durability, convenience and efficiency. Write.

DU BOIS IRON WORKS
Established 1877
805 Brady Street Dubois, Penna.



The Basis Of Economy

in any power plant is the boiler system. If you appreciate that fact you will do well to investigate

Our Safety Water Tube Boiler

Built for any pressure from 125 to 300 pounds. Meets all the high duty requirements of modern triple and quadruple expansion and compound engines. Perfect circulation, remarkable economy, and freedom to expand and contract, are features.

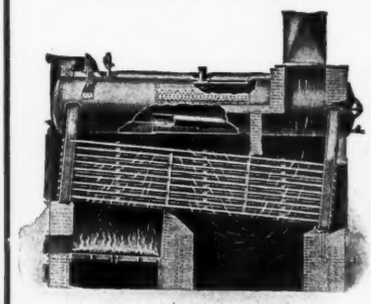
Ask for illustrated catalog and latest test report.

Oil Well Supply Co.,
Pittsburgh, Pa.

Boiler Works Dep't., - - OSWEGO, N. Y.

Branch Offices—NEW YORK, PHILADELPHIA.

Water Tube Boilers



All Wrought Steel Construction

Ask for New Catalog P. W.

ESTABLISHED 1865.

E. KEELER CO.
Williamsport, Pa.

New York, Philadelphia, Chicago, San Francisco, Wilkesbarre and New Orleans.

Alberger Condenser Co.

Condensers, Cooling Towers, Vacuum Pumps, Heaters

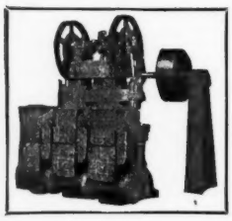
95 Liberty St. New York

Centrifugal, Volute, and Turbine Pumps

Alberger Pump Co.

Deming

Ask for Catalogue "G" and treatise "Feeding Boilers."



For any service. **Power**

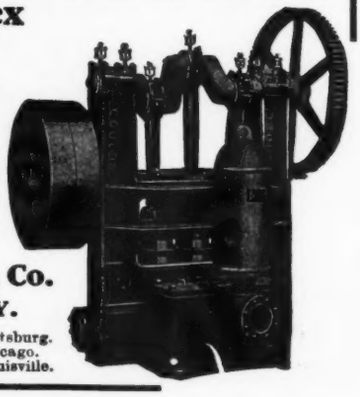
For operation by any power. **Pumps**

The Deming Company
Agencies in Principal Cities
Salem, Ohio

The Many Installations of GOULDS Efficient Triplex Power Pumps

For Municipal Water Works
Boiler Feeding
Hydraulic Elevators
Mine Pumping
General Water Supply, Etc.

Have fully demonstrated their practicability and efficiency for these important services.



The Goulds Mfg. Co.
Seneca Falls, N. Y.

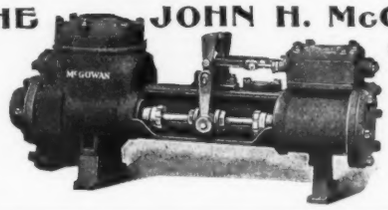
New York. Philadelphia. Pittsburg.
St. Louis. New Orleans. Chicago.
Los Angeles. San Francisco. Louisville.

MORRIN CLIMAX BOILERS

Have large heating surfaces and have proved their ability to produce more steam per pound of coal than any other make. They are the kind that save money. Write for booklet.

MORRIN CLIMAX BOILER WORKS, - - BROOKLYN, N. Y., U. S. A.

THE JOHN H. McGOWAN CO.

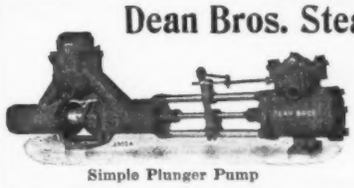


Cincinnati, Ohio

Builders of
PUMPING MACHINERY
Single Duplex and Fly-Wheel Types
Water Works Pumping Engines

Dean Bros. Steam Pump Works

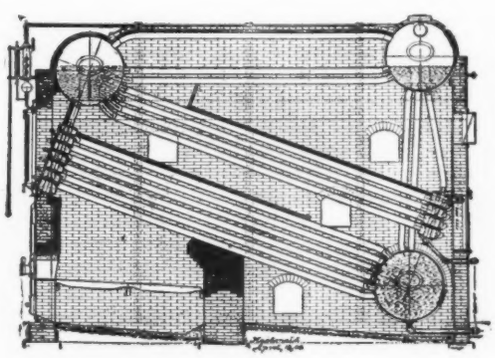
INDIANAPOLIS



Simple Plunger Pump

Simple and Duplex Boiler Feeders. Jet and Surface Condensers. Power and Electric Pumps.

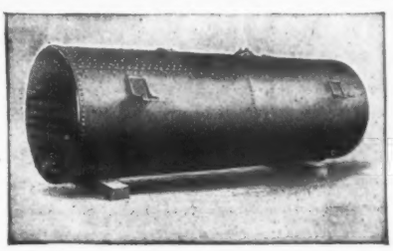
Robb-Mumford Water Tube Boiler



Free expansion of tubes—Perfect water circulation—Dry or superheated Steam—Half the usual number of handholes.

Robb-Mumford Boiler Co.,
South Framingham, Mass.

New York Office, 90 West Street.
Built in Canada by Robb Engineering Co., Ltd., Amherst, N. S.



WICKES Horizontal Tubular Steam Boilers

HIGHEST GRADE

THE WICKES BOILER CO.

Also Manufacturers of the Wickes Vertical Water Tube Safety Steam Boilers
Main Office and Works, Saginaw, Mich.

SALES OFFICES:
1411 West St. B'ld'g., West and Cedar Sts., New York City.
1139 AmericanTrust B'ld'g., Chicago, Ill.
Penobscot B'ld'g., Detroit, Mich. Empire B'ld'g., Pittsburg, Pa.
601 Brown-Marx B'ld'g., Birmingham, Ala.

HEINE WATER TUBE BOILERS

AND SUPERHEATERS

All Flange Steel Construction

Send for { Boiler Logic and Superheater Logic

Heine Safety Boiler Co. 421 Olive St., St. Louis, Mo

THE BABCOCK & WILCOX COMPANY

85 LIBERTY STREET, NEW YORK

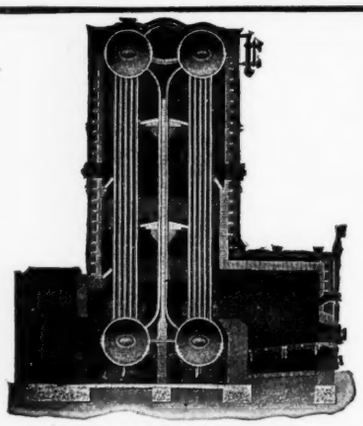
WATER TUBE STEAM BOILERS

STEAM SUPERHEATERS—MECHANICAL STOKERS

Barberton, Ohio — WORKS — Bayonne, N. J.

BRANCH OFFICES

BOSTON—Delta Building
PHILADELPHIA—North American Building
SAN FRANCISCO—99 First Street
PITTSBURG—Farmers Deposit Nat. Bank Building
NEW ORLEANS—533 Baronne Street
DENVER—435 Seventeenth Street
SALT LAKE CITY—Atlas Block
CHICAGO—Marquette Building
ATLANTA, GA.—Candler Building
CLEVELAND—New England Building
MEXICO CITY—7 Avenida Jurez
HAVANA, CUBA—116½ Calle de la Habana
LOS ANGELES—Trust Building
CINCINNATI—Traction Building
SEATTLE—Mutual Life Building



TYPE B

THE RUST
WATER TUBE
BOILER

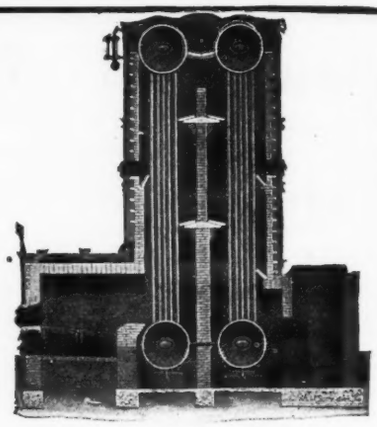
SAFE, SIMPLE, DURABLE,
ECONOMICAL, ACCESSIBLE

Write for Report of Tests by William Kent.

THE RUST BOILER CO.,

PITTSBURGH, PENNA.

Branch Offices: New York, 50 Church Street; Birmingham, Alabama, First National Bank Building.

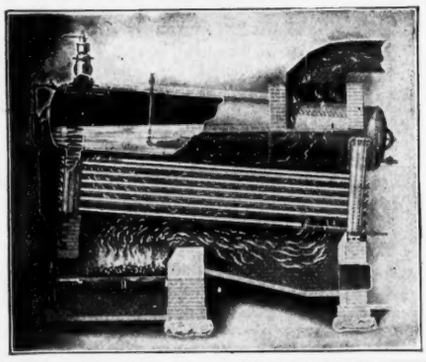


TYPE O

PARKER BOILER CO.
WATER TUBE BOILERS—SUPERHEATERS.
PHILADELPHIA, PENNA.
New York—Pittsburg—Chicago—Denver—San Francisco.

Foster Superheaters
Prevent condensation in long steam pipes.
POWER SPECIALTY CO.,
111 BROADWAY, NEW YORK.

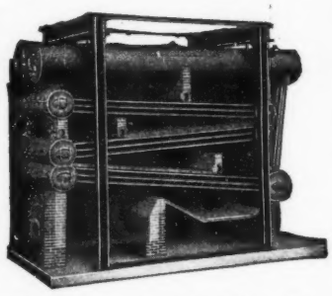
FRANKLIN WATER TUBE BOILER



BUILT BY
FRANKLIN BOILER WORKS CO.,
TROY, N.Y.
SALES OFFICE
39 Cortlandt St.,
New York, N. Y.

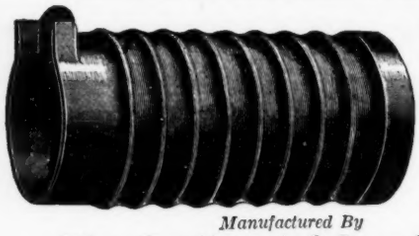
STEEL THROUGHOUT

There is not an ounce of cast iron in the construction of the
Vogt Water Tube Boiler
Write for our descriptive circular.



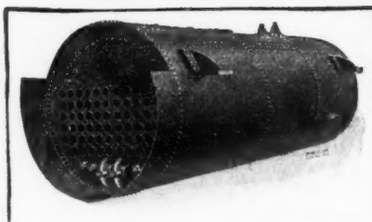
Henry Vogt Machine Co., Inc., Louisville, Ky.

Morison Suspension Furnaces
For Land and Marine Boilers
also—FOX CORRUGATED FURNACES.



Uniform Thickness
Easily Cleaned
Unexcelled for Strength

Manufactured By
The Continental Iron Works
Near 10th and 23d Ferries, West and Calyer Streets.
Brooklyn, N. Y.



KEWANEE BOILERS
Are Boilers of CHARACTER

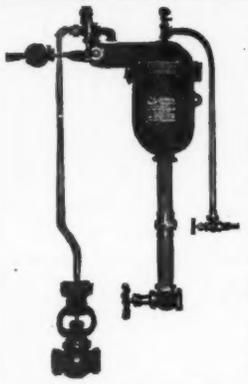
They bear the mark of superiority. They are built by mechanics, are strong, solid, substantial, efficient, durable. Have the name KEWANEE in your specifications.

KEWANEE BOILER COMPANY
KEWANEE, ILLINOIS.

Edge Moor Boilers
—WATER TUBE—
EDGE MOOR IRON CO., Edge Moor, Delaware

Large Units a Specialty.

Send for Catalog S.



The Vigilant
Feed-Water Regulator

for steam boilers was the first in the *field*, and has the longest and best record of any of these devices.

Costs Less to Operate and Maintain

Constructed on a different and better principle than any other.
Investigate it and the

FULTON PUMP GOVERNOR

and send for latest catalogue with list of users.
A guarantee from a responsible firm with every machine.

THE CHAPLIN-FULTON MFG. CO.
Pittsburg, Pa.

J. S. Ward, Agt., 79 S. Jefferson St. Chicago.

The overload capacity of **C-W** electric generators makes them popular with the engineer. In emergencies they do better than is expected of them. Bulletin 80M describes our D. C. machines.

CROCKER-WHEELER COMPANY
Ampere, N. J.

This Governor Says
"No Racing"

to Air Compressors and all types of pumps working under pressure.

For reliability and ease of regulation, get the FISHER PUMP GOVERNOR. It cannot get out of order, saves fuel and is made to control ANY PRESSURE up to 8,000 lbs. per sq. inch. Sold on trial; satisfaction guaranteed.

FISHER GOVERNOR CO.
MARSHALLTOWN, IOWA

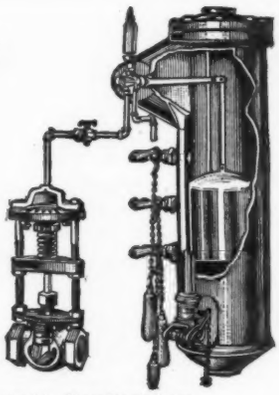
York Manufacturing Co.
York, Pennsylvania

We manufacture all machinery and parts needed to equip a complete Ice or Refrigerating plant—

Machines, Condensers, Tanks, Cans, Coolers, Piping, Boilers and Ammonia Fittings.

of all kinds. We employ over 1,250 men in the manufacture of Ice and Refrigerating Machinery exclusively. Catalogue sent upon request.

THE
BERRY
Safety
Automatic
Feed Water
REGULATOR
Send for Catalogue



BERRY ENGINEERING COMPANY
Chester, Penn.
Metropolitan Office, 136 Liberty St., New York City.

"True in the long run."

If you had what is lost in breakdowns, you could build a railroad.

We are fighting the liability to leaks and breaks with all our might in our smallest fittings.

True, it costs a trifle more to install, but—in the long run—

Fitting Catalog "D"
"The Fittings That Don't Leak."

THE TRIUMPH ICE MACHINE CO.,
Cincinnati.

Lammert & Mann

Engineers and Machinists

157 S. Jefferson Street, CHICAGO

WE MAKE A SPECIALTY OF

Corliss Engine Repairs. Engines Indicated.
General Jobbing. Repairing Engines.
Pumps, etc., all kinds Special Machinery.
Pulleys, Hangers, Shafting, etc. Oil Dash Pots.

Westinghouse

Single-Phase Motor

Adapted for all classes of service, belted or geared. Will operate at a distance from point of control by knife-blade switch or any automatic float or pressure switch. The result of years' experience in single-phase motor building.

See Circular No. 1153 for fully illustrated particulars

Westinghouse Electric & Mfg. Co.

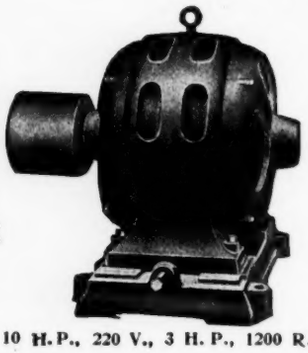
Atlanta, Baltimore, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Kansas City, Los Angeles, Minneapolis, New Orleans, New York, Philadelphia, Pittsburg, St. Louis, Salt Lake City, San Francisco, Seattle, Syracuse

Canada: Canadian Westinghouse Co., Ltd., Hamilton, Ontario. Mexico: G. & O. Braniff & Co., City of Mexico.

TRIUMPH
INDUCTION
MOTORS

HIGH EFFICIENCY
HIGH POWER FACTOR
COOL RUNNING

2 AND 3 PHASE



1 TO 75 H. P.

10 H.P., 220 V., 3 H.P., 1200 R.P.M.

Triumph Electric Co.,

Main Office and Works:
CINCINNATI, OHIO
BRANCHES IN ALL LARGE CITIES

FORT WAYNE ELECTRIC WORKS
Wood Systems

The Motor

with a record for reliable, unvarying service—that satisfies the most users most of the time in the most varied applications—the Fort Wayne motor.

Type EF, Direct Current Motor.

Fort Wayne Motors are particular motors for particular service with particular service from every motor.

712

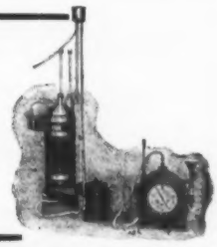
SALES OFFICES — Main Office: FORT WAYNE, IND. — IN MOST LARGE CITIES

ECONOMY IS BASED ON FACTS

You should always know the heat value of the gas you use.
The Sargent Gas Calorimeter is as essential to the Gas Engineer as the indicator is to the Steam Engineer.
It is accurate, is the very best of construction, and saves the operator 50% of his time.

Write for Catalog and "Testing of Inflammable Gases" Booklet

SARGENT STEAM METER CO., 271-285 E. Madison St., Chicago, Ill.



WHAT PART OF YOUR POWER DO YOU USE?

The plain, simple brute force which can be reckoned in horse power or the convenient, versatile (we may say "intelligent") power afforded by Northern Apparatus? ¶You need better power than ordinary methods afford. Northern Machines and methods are best. They assure maximum convenience in the arrangement of production machines, maximum economy in the application of labor and maximum profits. ¶An intelligent discussion of the use of Northern Machines in your work necessitates that we know what your work requires. Tell us and ask us incidentally for booklet 839.

NORTHERN ELECTRICAL MANUFACTURING CO., Madison, Wis., U.S.A.
Standard and Special Electrical Machines. 887

THE ONLY METAL POLISH

that works quick and easy and keeps its lustre. Holds old trade and makes new. IT DOES NOT DETERIORATE. Established 16 years.

3-Ounce Box for 10 cts. 5-Pound Pails, $1.00

Sold by Agents and Dealers all over the world. Ask or write for Free samples. Highest Award, Chicago, '93; St. Louis, '04.

GEO. W. HOFFMAN, Expert Polish Maker,
295 E. Washington St., INDIANAPOLIS, IND.
Branches—New York, Chicago, San Francisco.

De LaVergne Machine Co.

NEW YORK

KOERTING GAS ENGINES

Hornsby-Akroyd Oil Engines, Refrigerating and Ice Making Machinery

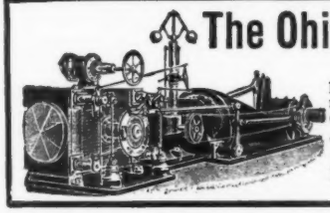
SHEPHERD ENGINES

ARE distinguished above all others for—**Economy—Close regulation—Reliability—Durability.** They cost a little more, but you'll never be sorry.

WRITE FOR ILLUSTRATED CATALOG.

SHEPHERD ENGINEERING CO., Williamsport, Pa.

The Ohio Corliss Engine



For hard work, heavy loads and high-speed, the Ohio shows close regulation and runs smoothly and quietly.

THE GRIFFITH & WEDGE CO.
Est. 1840. ZANESVILLE, OHIO

REEVES ENGINES

MAINTAIN THEIR ECONOMY AND SUPERIOR RUNNING QUALITIES.

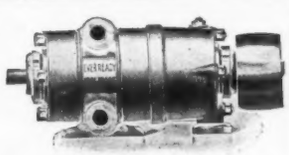
ASK ANY USER

REEVES ENGINE AND MACHINE CO., Trenton, N. J.

We Manufacture

AN ECONOMICAL AND DURABLE ROTARY ENGINE

Send for Catalogue.



Ball-Cooley Engineering Co.
316 HUDSON ST., NEW YORK CITY and 159 GREEN ST., BOSTON.

MOUND TOOLS. FOR THE ENGINE ROOM.

This cut represents our new set of 20 tools gotten up for use in the engine room. Strictly high-grade tools with all the good points of toolsmithing in their make-up. Conveniently arranged in finished Oak Case and every tool is guaranteed.

No. 20 Set of 20 Tools . . . $4.00.

Book "Engineers' Chums" free. Address Dept, B

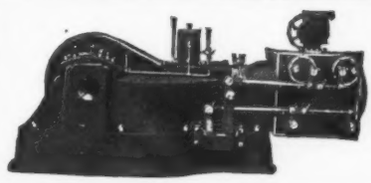
MOUND TOOL AND SCRAPER CO.
1606-1608 N. BROADWAY, ST. LOUIS, U. S. A.

RICE & SARGENT

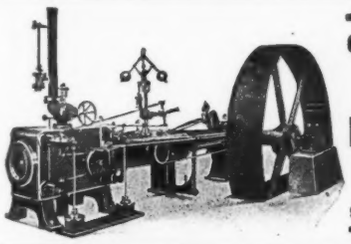
CORLISS ENGINES

For Reliability and Economy.

Built by
PROVIDENCE ENGINEERING WORKS,
Providence, Rhode Island.



THE BALL ENGINE CO. ERIE, PA.



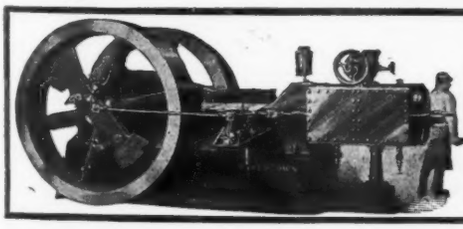
CORLISS ENGINES

Refrigerating and Ice Making Machinery

THE VILTER MFG. CO.
910 Clinton St., Milwaukee, Wis.

The Allan Metal for Pistons and Bearings.

A. Allan & Son 482 Greenwich St. N.Y.



Good Engines
for every power purpose. Ask for Catalog.

Watertown Engine Co.,
Watertown, N. Y.

ALBERGER TANDEM GAS ENGINES

ACCURATE REGULATION FOR ELECTRIC SERVICE-AUTOMATIC CUT-OFF AND RITES FLY-WHEEL GOVERNOR

A.H. ALBERGER COMPANY

45 TO 600 H.P. USING NATURAL GAS
35 TO 500 H.P. USING PRODUCER GAS

695-697 ELLICOTT SQ.
BUFFALO N.Y.

Weiss Counter-Current Condenser.

We are sole licensees in the United States for the manufacture and sale of this Condenser, and will gladly send particulars to any one interested.

We guarantee any desired vacuum, using less cooling water and of higher temperature than other apparatus.

All contracts made upon positive statements as to relative volume of steam and water.

Southwark Foundry & Machine Co.

PHILADELPHIA, PA.

ENGINE AND BOILER BARGAINS

ENGINES

20 x 42 Allis, Corliss	16 x 32 Buckeye, Automatic
18 x 42 Hamilton Corliss	14 x 24 Atlas, Automatic
18 x 36 Wright, Corliss	13½ x 15 Taylor, Automatic
14 x 24 Wright, Corliss	12 x 18 Brownell, Automatic
12 x 24 Wetherill, Corliss	12 x 14 Green, Automatic
10 x 30 Hamilton, Corliss	12 x 12 N. Y. Safety, Automatic

Also large assortment of Automatic and Throttling Engines of other sizes.

BOILERS

84 x 18, 78 x 16, 72 x 18 High Pressure, 72 x 16, 66 x 16 and smaller sizes of Horizontal Tubular Boilers, also Vertical and Fire Box Boilers from 5 to 60 H. P.

Heaters, Pumps, Tanks, Saw Mills, Iron Working Tools, etc., etc.
Write for bargain list.

We are the sole manufacturers of the celebrated "Leader" Injectors and Jet Pumps.

THE RANDLE MACHINERY CO.
1768 Powers St., CINCINNATI, OHIO.

PRODUCER GAS

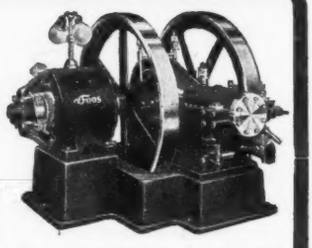
THE CHEAPEST POWER IN THE WORLD

GAS ENGINES, GAS PRODUCERS
COMPLETE PLANTS INSTALLED

BROOMELL, SCHMIDT & STEACY CO.,
YORK, PENNSYLVANIA.

SATISFACTORY SERVICE
FROM A GAS ENGINE

Is assured the careful buyer who, after investigating the gas engine proposition thoroughly, invests in a

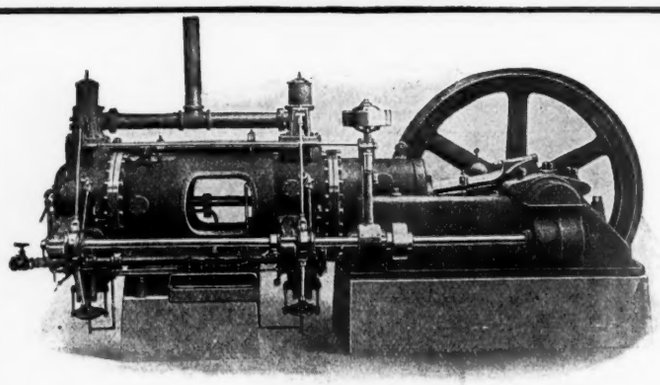


FOOS Gas or Gasolene Engine

The patented wipe spark igniter insures the absence of all ignition troubles, while the accessible design makes it simple for any one to properly adjust the Foos.

In fuel economy The Foos, with a proven thermal efficiency of 28%, ranks second to none. If you want more facts ask for Catalog No. 16.

THE FOOS GAS ENGINE CO., Springfield, Ohio



WARREN GAS ENGINES

Horizontal and Vertical
Types up to 700 H. P.

NOT AN EXPERIMENT

Economy and Reliability Have Been Demonstrated by Actual Service

FULLY GUARANTEED

For All Street Railway, Electric Light and Power Requirements

STRUTHERS-WELLS COMPANY,
WARREN, PENNA.

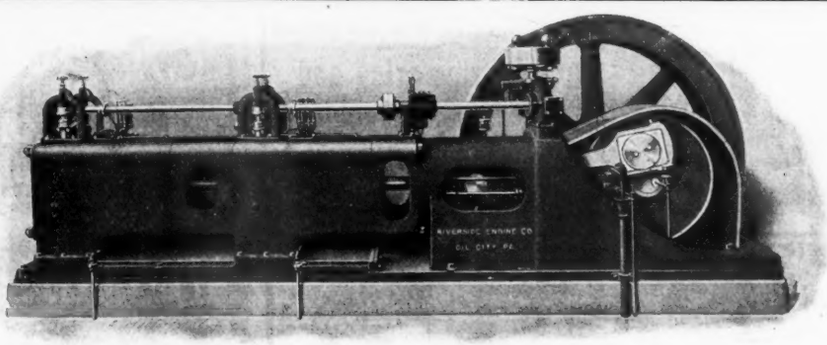
New York Office, 26 Cortlandt Street.

Pittsburg Office, 310 House Building.

NO BACK-FIRE NO PACKINGS

to blow out and none of the other troubles that make life weary for the Engineer and the Power Plant Man.

Riverside Engines equal the good old faithful steam engine for reliability. They are superior in every detail to any other engine ever built. Write!



RIVERSIDE ENGINE CO, - OIL CITY, PA.

New York City, 50 Church St. Pittsburg, Keenan Bldg. Cleveland, Holbeck Co., 924 Rockefeller Bldg. Fitchburg, Mass., The Brown-Russell Co. Atlanta, The W. E. Austin Co., Candler Bldg. Indianapolis, Mr. F. Louis Egan, 1130 Congress Ave.

YOURS

ON A MINUTE'S NOTICE

We have for immediate delivery:

One 18-inch by 42-inch girder frame engine, left hand, 90 revolutions, rated at 250 h.p.; wheel 14-ft. diameter by 48-inch face.

One 19-inch by 42-inch girder frame engine, right hand, 100 revolutions, rated at 280 h.p.; wheel 14-ft. diameter by 33-inch face.

The above are **new** engines.

One 14-ft. diameter by 28-inch face pulley, turned for belt. Hub bored 11-inches diameter. Wheel weighs 15,000 pounds.

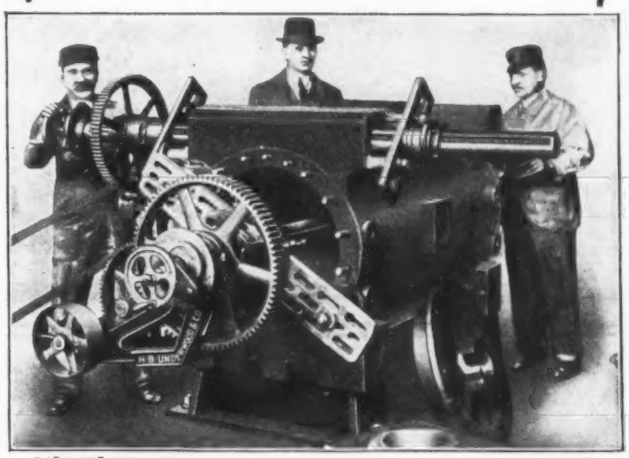
Get busy and communicate with us.

C. H. BROWN ENGINE CO., Inc.

FITCHBURG, MASS.

Chicago Representative—FRANK H. POND & Co., Fisher Bldg.

A Dollar For A Half



24"X 48" CORLISS ENGINE, REBORING CYLINDER AND VALVE SEAT.

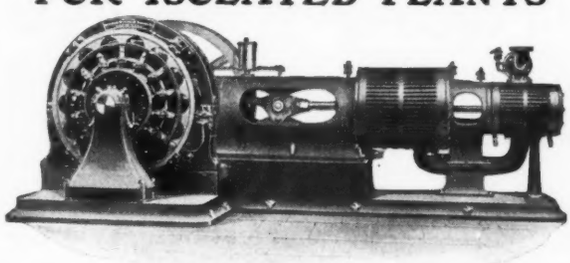
If you have us rebore your cylinder where it stands, or make your other engine repairs with our portable tools you will realize a fifty per cent. saving and avoid all unnecessary delay. Write.
AMMONIA CYLINDERS INDICATED.

H. B. Underwood & Co.,

ESTABLISHED 1870

1027 Hamilton St., Philadelphia, Pa., U. S. A.

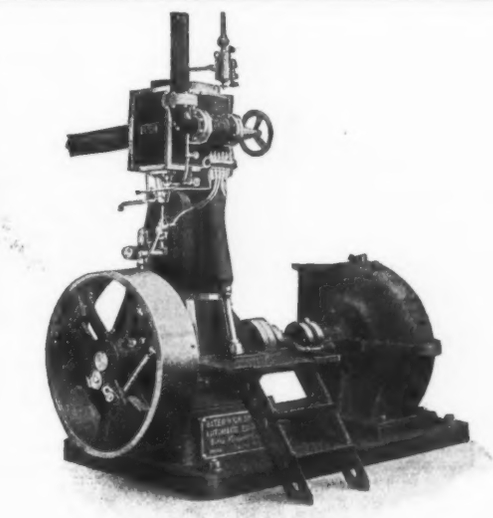
FOR ISOLATED PLANTS



RIDGWAY GENERATING SETS are superior to all others because they require less attention and almost no repairs. Write.

RIDGWAY DYNAMO & ENGINE CO.

WORKS, RIDGWAY, PA., U. S. A.



Bates Vertical Automatic High Speed Engine for connection to Pumps. Especially adapted for

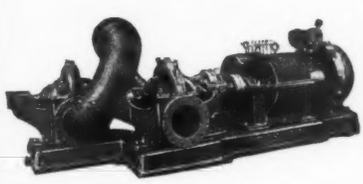
WATER WORKS, IRRIGATION

and other places where it is desired to move a large volume of water at small expense.

CATALOG FOR THE ASKING.

BATES MACHINE CO., Joliet, Ill.

DE LAVAL



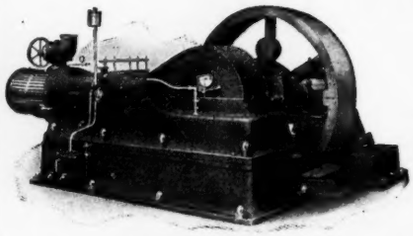
De Laval Turbine-Driven Series Pump.

Steam Turbine Motors
Steam Turbine Dynamos
Steam Turbine Blowers
Steam Turbine Centrifugal Pumps
Electric-Motor Centrifugal Pumps

Send for Catalog No. 20.

DE LAVAL STEAM TURBINE CO., Trenton, N.J.

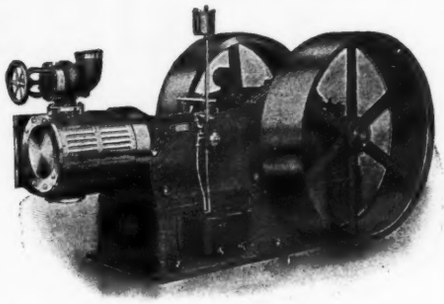
Skinner Engines



SIDE CRANK TYPE

CENTER CRANK
SIDE CRANK
SINGLE and FOUR VALVE

Skinner Engine Co.,
Erie, Pa.



CENTER CRANK TYPE

BUCKEYE ENGINE COMPANY,

SALEM, OHIO

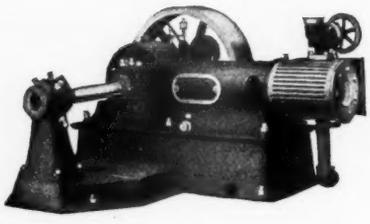
BUILDERS OF HIGH CLASS

STEAM AND GAS ENGINES

HIGH IN DUTY, SUPERIOR IN REGULATION
AND
ABSOLUTELY RELIABLE
CORRESPOND WITH US BEFORE PURCHASING
CATALOGS ON APPLICATION

No Noise, Excessive Heating Or Distress in Any Part

"Erieco" Self Oiling Engine frames are finished at one setting to secure perfect alignment.

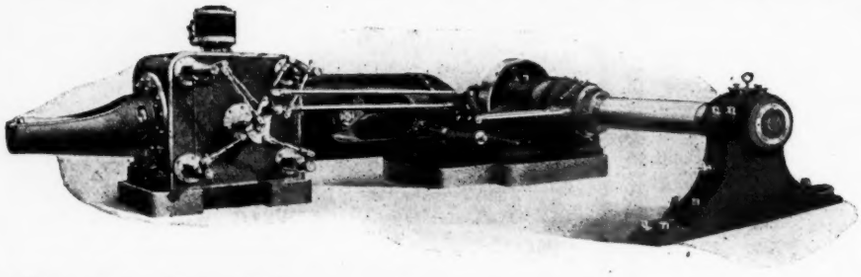


Ask for a description of the Riblet Automatic Governor and other superior features.

ERIE MFG. & SUPPLY CO.

1203 PEACH STREET
ERIE, PA.

The Valve Travel Never Varies



The Clark Heavy Duty Corliss Engine

is unequalled for close regulation, low steam consumption and durability without repairs.

These advantages result from perfect valve seats, heavy duty bed with bored guide, extra large main bearings, and numerous other features for which write.

Clark Brothers Company, - Belmont, N. Y.

Robt. Wetherill & Co., Inc.

CHESTER, PENNSYLVANIA.

CORLISS STEAM ENGINES

Manufacturers

POWER PLANTS BOILERS

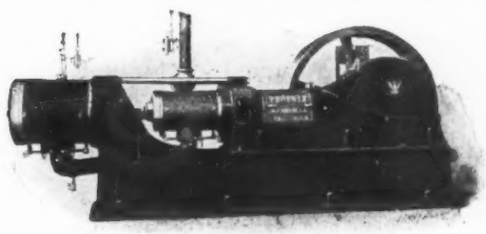
Phoenix Iron Works Company

BUILDERS OF

AUTOMATIC CUT-OFF ENGINES

ALSO

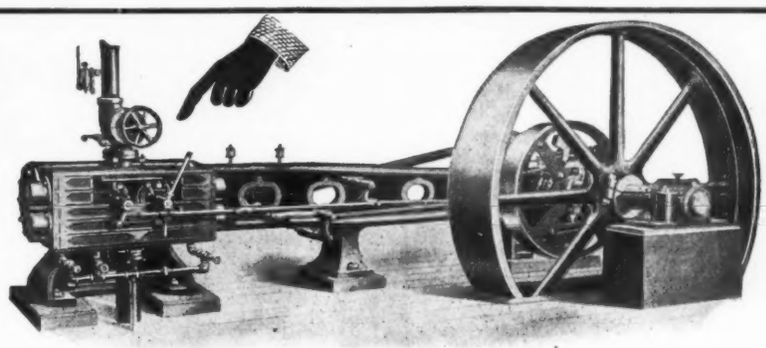
BOILERS, HEATERS, TANKS AND GAS CONDENSERS



General Offices and Works: - - MEADVILLE, PA.

Repeat Orders

are an infallible sign of satisfaction. *Our business is largely made up of repeat orders.*



Geo. H Connor, 509 Mutual Life Bldg., Philadelphia. E. H. Ludeman & Co., 165 Broadway, New York. H. J. Gebhardt, 1501 Fisher Bldg., Chicago. W. C. Teas, Chattanooga, Tennessee. Western Trading Co., San Francisco.

One hour's time per year keeps each of the thousands of Fitchburg Engines, perfectly steam tight.

WRITE!

Fitchburg Steam Engine Co.

Fitchburg, Mass.

FINE RESULTS FROM COOPER CORLISS ENGINES

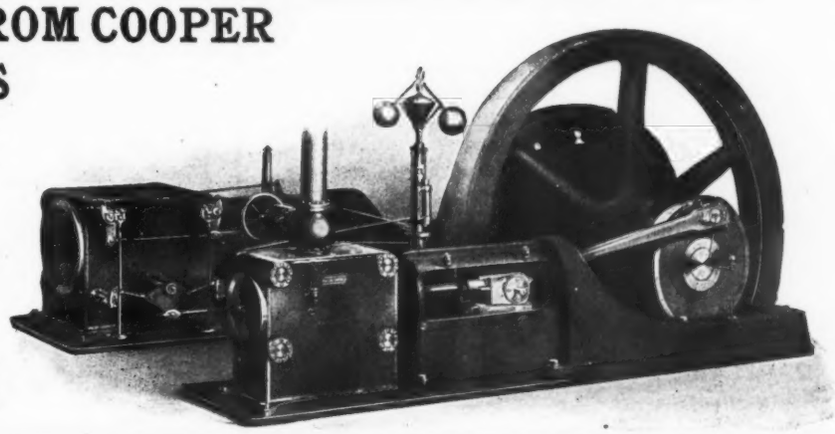
are being secured in all classes of service. We are Engine Builders and also do Complete Steam Plant Engineering.

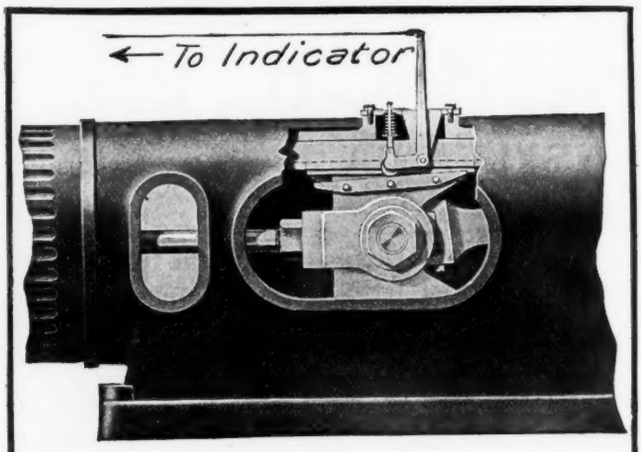
The C. & G. Cooper Co.,

Mt. Vernon, Ohio.

Branch Offices.

New York, 918 Bowling Green Bldg.; Boston, 411 Weld Bldg.; Pittsburg, 604 Frick Bldg.; Philadelphia, Drexel Bldg.; Atlanta, 310 Candler Bldg.; Charlotte, N. C., Court House Square; Chicago, 1539 Frist Nat'l Bank Building.





EASY TO INDICATE
AMERICAN-BALL ENGINES.

As an example of the thorough-going way in which AMERICAN-BALL ENGINES are built notice the new indicator reducing motion, built into the frame. You just hook on the cord, start the motion by pressing a detent with your finger, take the card, and stop the the motion by shifting the detent again. Leave the cord hooked in place and repeat for each time.

This device gives a theoretically correct motion, is selt contained and is always ready and in place. You don't have to hook any swing lever to the roof or erect a temporary structure to support a pantograph lazy tongs or other mechanism.

This is only one of the superior features of our engines. The AMERICAN - BALL ANGLE COMPOUNDS for instance, have the distinctive advantage that they take up half the space of a single engine of the same power, weigh little for their power, save foundation costs both on account of smaller floor space and because of the absence of vibration, save the labor which others require for frequent oiling and adjustment, and speed regulation, and cannot be equaled by other types of engines of the same capacity.

AMERICAN-BALL ENGINES represent 30 years of progressive development.

Write for Bulletin No. 14.

AMERICAN ENGINE CO.

22 RARITAN AVE., BOUND BROOK, N. J.

(2)

Small Curtis Turbine Generators

For Direct Current
20, 25 and 35 kilowatts

These sets consist of a Curtis Steam Turbine, direct connected on the same shaft to a shunt or compound wound General Electric Generator. The turbine is the single stage, non-condensing type with three sets of bucket wheels, mounted on the same hub. Between the wheels are the intermediate or stationary buckets. The nozzles are contained in a separate casting. Steam is admitted through a strainer to the steam chest and is passed through balanced valves operated by the governor, directly to the steam nozzles, thence through the turbine and to the exhaust.

Turbine end view of 20 kw. Curtis Turbine Generator. Speed 4500 r. p. m. 125 volts. Length 5½ ft. Weight 1850 lbs.

These sizes may be arranged to operate at any steam pressures above 80 lbs., and no difficulty is encountered in using steam superheated to 200 degrees F. As no internal lubrication is required in the turbine the exhaust steam is absolutely clean and can be turned into a heating system without risk of clogging the system with oil.

General Electric Company

Principal Office: Schenectady, N. Y.

New York Office: 30 Church Street.

Sales Offices in all large cities.

1791

If You Sign A Yearly Oil Contract

you'll be compelled to nurse along something that has been dead a long time. On the other hand

KEYSTONE
TRADE MARK
REGISTERED U.S. PAT. OFF.

Grease

has been appreciated for years by engineers who don't want any "dry bones" or dry bearings rattling around their plants. It is the "live" way to lubricate modern machinery as it outclasses oil in every point, lasts fifty times as long, and never melts and runs away.

Keystone Grease is "as pure as the driven snow," it does not gum and clog bearings, and every particle is used up in actual lubrication. Try it.

See Our Advertisement On Page 3

Keystone Lubricating Co.

Department B. **PHILADELPHIA, PA.**

New England Office—10 Oliver St., Boston, Mass.
New York City Office—96 Warren St.
Southern Office—610 Chartres St., New Orleans, La.

Chicago Office—1210 Tacoma Bldg.
Northwestern Office and Warehouse—502 McPhee Bldg., Denver, Col.
San Francisco Office and Warehouse—268 Market St.

There is no mystery about

PALMETTO
PACKING

A glance at the materials used and method of construction will convince any engineer that Palmetto does remain soft and resists heat. Braided round and square for large stems. Twist (on 1 lb. spools) for small stems. Working samples sent free.

GREENE, TWEED & CO.
Sole Manufacturers
109 DUANE STREET NEW YORK

THE BRISTOL COMPANY
SPECIALISTS IN
Recording Instruments
FOR
PRESSURE
TEMPERATURE
AND
ELECTRICITY

Wm. H. Bristol Recording Shunt Ammeters
And
Bristol's Recording Pressure
And
Vacuum Gauges For Power Plants.

The BRISTOL CO., Waterbury, Conn.
BRANCH OFFICES
114 Liberty St., NEW YORK. 753 Monadnock Building, CHICAGO.

STARRETT
SPEED INDICATORS
OR REVOLUTION COUNTERS

No. 104.—This indicator may be run at the highest speed required without heating. The working parts are encased. Dial has two rows of figures, reading right or left as the shaft may run. Steel pointed spindle with rubber tips for both pointed and centered shafts. The (O) mark may be instantly set at starting point.

Price, Postpaid, $1.00

No. 107.—Has all the good points of the above, and in addition has a hard rubber handle for insulation when used on electrical machinery. It also automatically registers the number of revolutions up to 5,000, thus relieving the mind from keeping count.

Price, Postpaid, $3.00

Send for FREE Catalogue, No. 17-R, of Fine Tools.

The L. S. Starrett Co.
Athol, Mass., U. S. A.